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# **User's Manual**

# **Model DRC-80**

## **Digital Cryogenic Thermometer**

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## Specifications, DRC-80 Thermometer

### Input:

**Temperature Range:** 1.4 to 330K with standard DRC Sensor (to 380K with other Sensors).

**Sensor:** Silicon Diode (order separately). DT-500-DRC, DT-500CU-DRC-36 or any calibrated DT-500 Series Diode. See below for proper response curve.

**Sensor Input:** Dual-sensor input. 4-terminal input for each sensor. Selection is via front-panel pushbuttons.

**Sensor Excitation:** 10-microampere current source. Stability  $\pm 0.005\%$ .

**Sensor Response Curve:** Domestic US units require Sensor Curve "D". Export units require Sensor Curve "E". Sensor curves subject to change, refer to manual for proper curve when reordering Sensors. Curves to match existing Sensors available on special request. See also DRC-Precision Option.

**Input Resistance:** Greater than 1000 megohms.

**Maximum Sensor Power Dissipation:** 25 $\mu$ W at 4.2K

### Temperature Readout:

**Display:** 4-digit, 1.1cm (0.43") LED shows temperature directly in Kelvin.

**Resolution:** 0.1K. "Scale Expand" increases resolution to 0.01K for temperatures below 30K, 0.05K from 30K to 100K (no increase in accuracy).

**Accuracy (20-25°C ambient):**  $\pm 0.5$ K at 4K and 77K,  $\pm 1.0$ K at 330K with standard Sensor. See DRC-Precision Option for accuracy with Lake Shore calibrated Sensor.

**Temperature Coefficient (10-20°C and 25-45° ambient):**  $\pm 0.01$ K/°C.

**Response Time:** Less than 1 second to rated accuracy.

### General:

**Monitor Output:** Buffered output of Display Sensor voltage (additional outputs listed below as options).

**Dimensions, Weight:** 216mm wide x 102mm high x 330mm deep (8.5 in x 4 in x 13 in). Style L, half-rack package. Net weight 3.6 kg (7.9 lbs).

**Power:** 90-110, 105-125, or 210-250VAC (switch-selected), 50 or 60Hz.

**Accessories Supplied:** Mating connectors for sensor inputs and monitor, instruction manual.

### Options and Accessories Available:

**Model 8022.** Parallel BCD output for DRC-80. TTL compatible. Provides BCD output of temperature in Kelvin and Sensor selected (either from front-panel or optional SW-10A).

**Model 8024.** IEEE-488 output for DRC-80. Provides digital output of temperature in Kelvin and Sensor selected (either from front-panel or optional SW-10A).

**Model 8025.** Analog output proportional to Kelvin temperature for use with recorders or other readouts. 10mV/K at  $< 10$  ohm output resistance (field installable).

**Model 8022/25.** Combination of 8022 (BCD output) and 8025 (Analog output) installed in same unit.

**Model SW-10A.** 10-Sensor Selector Switch for use with DRC Thermometer or Controller. Push-button selection of any one of up to 10 sensors. Connects to Sensor "B" position of instrument. Sensor selected is also identified via 8022 or 8024 digital interfaces. Dimensions: 216mm wide x 102mm high x 330mm deep (8½ in x 4 in x 13 in). Style L half-rack package.

**Model RM-3H.** Rack mounting hardware to mount either one or two Style L half-rack unit(s) in standard 3½" rack space.

**DRC-Precision Option:** Custom-programmed read-only-memory for DRC instruments which improves specified accuracy to 0.1K or better over a given calibration range. Any DT-500 Series Silicon Diode Sensor can be utilized. Requires that an appropriate calibration be purchased for the Sensor. Specify Sensor input position (A or B or 1-10 on SW-10A) to assure proper location of calibration within PROM. First calibration stored. Subsequent calibrations stored in same PROM.

**Model DT-500-DRC Sensor.** Silicon Diode Temperature Sensor for DRC-80 (1.5mm diameter x 4.1mm long). Specify response curve.

**Model DT-500CU-DRC-36.** Silicon Diode Temperature Sensor for DRC-80 (8mm diameter x 3.3mm thick with mounting hole). Specify response curve.

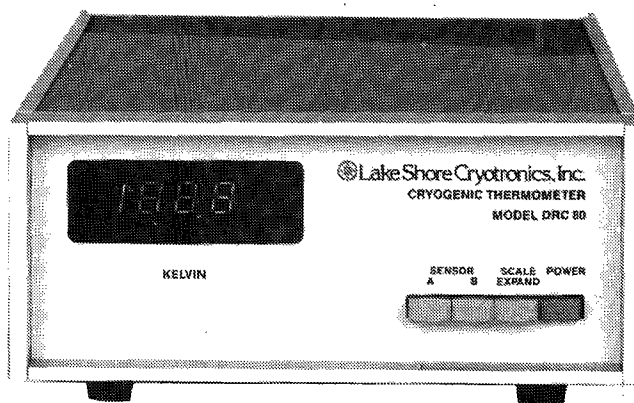


FIGURE 1.1 Model DRC-80 Digital Cryogenic Thermometer

## SECTION I

### General Information

#### 1.1 Introduction

The following is a description of the DRC-80 Cryogenic Digital Thermometer. The DRC-80 Series of instruments is designed to be used with the Model DT-500-DRC and DT-500CU-DRC-36 silicon diode sensors manufactured by Lake Shore Cryotronics, Inc.

Several different diode sensor curves are available for use with this instrument. When ordering replacement sensors, care must be taken to assure that the correct sensor curve is specified. Multiple curves are needed so that Lake Shore can assure the customer that replacement sensors will be available at any time in the future. For details, please see Section 1.4.

#### 1.2 Description

The DRC-80 Series is comprised of completely self-contained units providing direct digital readout in Kelvin temperature units and, for the controllers, temperature control by direct analog comparison between the sensor voltage and an analog equivalent of the digital temperature set point. The DRC-80 displays temperature to 0.1 Kelvin over its operating range of 1-400 Kelvin for normal operation. In the scale expand mode, the resolution is 0.01 Kelvin below 30 Kelvin and 0.05 Kelvin from 30K to 100 Kelvin.

The specified range of operation is 4.0 to 380K\* utilizing standard DRC series sensors which have been pre-selected to provide uniform characteristics over this range. These sensors conform to the standard table (see Table 3.3) to 0.5K or better below 77K and better than 1 Kelvin above 77K. The instrument, however, displays down to 1K although accuracy is only specified above 4K. Pre-selection allows the DRC-80 Series to be used with the DT-500-DRC and DT-500CU-DRC-36 sensors without adjustments of any kind. Since the standard sensors are interchangeable, the instruments may be used to read out any number of sensors with equal accuracy when selected through an appropriate switch such as the SW-10A.

The DRC-80 has dual sensor inputs. Sensor selection is made via front-panel pushbuttons.

As a standard feature, all units are equipped with buffered analog output of the display sensor voltage. This allows the instrument user the ability to record the display sensor voltage versus time or to use a digital voltmeter to measure the display sensor voltage directly. Since this output is buffered, a high input impedance recorder or voltmeter is not required.

\*If possible, temperatures above 330K should be avoided with DRC Series sensors since these sensors may slightly shift their values below 20K if heated above 330K.

If the sensor is calibrated by the user or by Lake Shore Cryotronics, Inc., temperature may be determined to approximately 10mK.

Five options are available with the DRC-80 Series of instruments. One option is an analog signal which is proportional to temperature (Model 8025) and has a sensitivity of 10 mV/K.

A second option is a ten-position switch (SW-10A) for multiple sensor readout. This switch is a separate half-rack box which plugs into the Sensor "B" position of the DRC-80. The sensor selected is also identified via digital interface of the DRC-80, if present.

Another option is a custom cut PROM (DRC-Precision Option) which corresponds to the calibration curve of the customer's DT-500 Series sensor. A combination of a calibration and custom cut PROM will increase display accuracy to better than .1 Kelvin over the calibrated range. Please note that any sensor may be used with this option, i.e., the customer is not restricted to the DRC Series sensors.

There are two computer options available; each will output the displayed temperature and sensor selected from the SW-10A. The Model 8022 is in a parallel BCD format while the Model 8024 is in the popular IEEE-488 format.

The DRC-80 Series is designed around an 3870 microprocessor and associated support circuits. The DRC curve is stored in a PROM which can handle up to 32 break points. The data consists of a table of temperature and voltage associated with each break point. These straight line segments can generate the DRC curve to an accuracy of better than 0.1 Kelvin over the entire temperature range (4.0 - 400 K).

### 1.3 Major Assemblies Supplied

The DRC-80 Series includes as standard equipment, in addition to the digital thermometer-controller, the following:

- A. Operating and Servicing Manual
- B. Two five Pin Plugs for Temperature Sensor Cables
- C. One seven Pin Plug for Monitor of Sensor Output Voltage and the DRC8-L/A option

Model DT-500 Series silicon diodes are not supplied as part of the DRC-80 instrument.

Complete Specifications, Accessory Equipment and Customs Options are listed in the front of the Manual.

#### 1.4 Ordering of Replacement or Additional Sensors

Two different sensor configurations are available for use with the Model DRC-80 Series instruments. These are the DT-500-DRC and the DT-500CU-DRC-36 sensors. Their description is included elsewhere in this manual. All sensor configurations are available if the diode is calibrated and a special PROM is cut.

More than one curve presently exists which can be used with the DRC-80 Series instruments. If additional sensors are ordered for use with your instrument, you must be certain to order the correct curve so that your instrument will have its stated accuracy. The proper curve may be determined in one of the following ways:

- A. Specify the sensor serial number that is currently being used with the instrument (serial number is found on the end of the plastic box in which the sensor was received).
- B. Specify the serial number of your instrument. Our records will indicate with which sensor the instrument is compatible.
- C. Remove the top of your instrument and observe the indicator on the PROM.
- D. The fourth way is to measure the diode voltage at 4.2K and give this value to Lake Shore Cryotronics, Inc. when re-ordering sensors.

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## SECTION II

### Installation

#### 2.1 Introduction

This section contains information and instructions necessary for the installation and shipping of the model DRC-80 Cryogenic Thermometer. Included are initial inspection instructions, power and grounding requirements, installation information and instructions for repackaging for shipment.

#### 2.2 Initial Inspection

This instrument was electrically and mechanically inspected prior to shipment. It should be free from mechanical damages, and in perfect working order upon receipt. To confirm this, the instrument should be inspected visually for obvious damage upon receipt and tested electrically by use to detect any concealed damage. Be sure to inventory all components supplied before discarding any shipping materials. If there is damage to the instrument in transit, be sure to file appropriate claims with the carrier, and/or insurance company. Please advise the company of such filings. In case of parts' shortages, please advise the company. The standard Lake Shore Cryotronics warranty is given on the title page.

#### 2.3 Power Requirements

Before connecting the power cable to line voltage, insure that the instrument is of the proper line voltage and fused accordingly. The line voltage and fuse are shown on the rear panel of the instrument.

The line voltage can be changed by switching line voltage selector switch (S2 - Figure 6.3 DRC-80 Component Layout) located on the main printed circuit board of the unit.

Nominal permissible line voltage fluctuation is  $\pm 10\%$  at 50 to 60 Hz.

#### 2.4 Grounding Requirements

To protect operating personnel, the National Electrical Manufacturer's Association (NEMA) recommends, and some local codes require, instrument panels and cabinets to be grounded. This instrument is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument.

#### 2.5 Installation

The DRC-80 Thermometer is all solid state and does not generate significant heat. It may therefore be rack mounted in close proximity to other equipment in dead air spaces. The heat from such adjacent equipment should not subject the thermometer to an ambient temperature in excess of  $50^{\circ}\text{C}$  ( $122^{\circ}\text{F}$ ).

As with any precision instrument, it should not be subjected to the shock and vibrations which usually accompany high vacuum pumping systems.

The recommended cable diagrams for the sensor diodes are shown in Figure 2.1 (a). The use of a four wire diode connection is highly recommended to avoid introducing lead IR drops which will occur if the alternate two lead sensor cable connection is used. For example, for a two lead connection, every 25 ohms of cable resistance corresponds to a .1 K error above 30 Kelvin. The alternate wiring scheme shown in Figure 2.1 (b) may be used for the diode in less critical applications where lead resistance can be kept small. The indicated shielding connections are the recommended standard practice to avoid ground loops.

## 2.6 Repackaging for Shipment

Before returning an instrument to the factory, should repair be necessary, please discuss the malfunction with a factory representative. He may be able to suggest several field tests which will preclude returning a satisfactory instrument to the factory when the malfunction is elsewhere. If it is indicated that the fault is in the instrument after these tests, the representative will provide shipping and labeling instructions for returning it.

When returning an instrument, please attach a tag securely to the instrument itself (not on the shipping carton) clearly stating:

- A. Owner and Address
- B. Instrument Model and Serial Number
- C. Malfunction Symptoms
- D. Description of External Connections and Cryostats

If the original carton is available, repack the instrument in a plastic bag, place in carton using original spacers to protect protruding controls, and close carton. Seal lid with paper or nylon tape. Affix mailing labels and "FRAGILE" warnings.

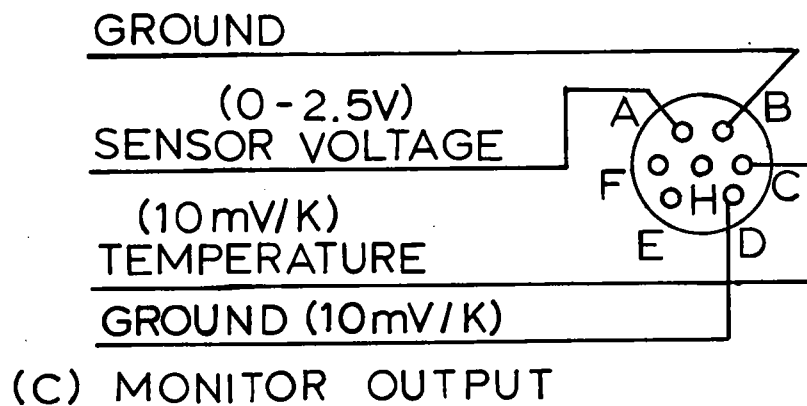
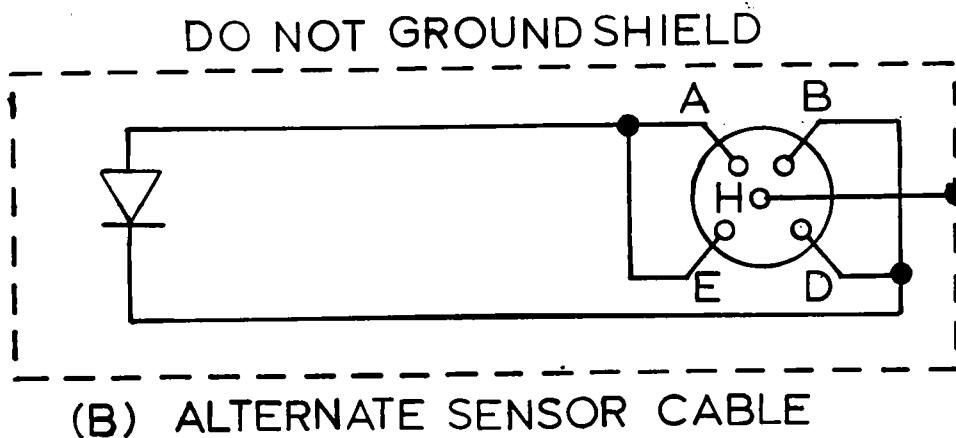
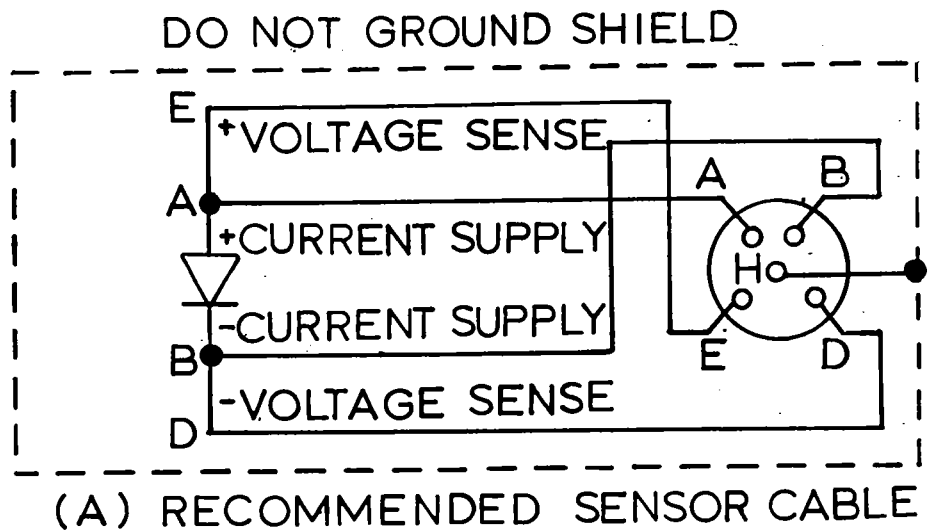


FIGURE 2.1 Sensor, Cable, and Monitor Connections

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## SECTION III

### Operating Instructions

#### 3.1 Introduction

This section contains a description of the operating controls and their adjustment under normal operating conditions, and typical controller applications. These instructions are based upon the instrument having been installed as outlined in Section II. The diode polarity as shown in Figure 2.1 (a), in particular, must be correct.

#### 3.2 Controls, Indicators, Connectors

The operating controls, indicators and connectors on the DRC-80 instrument's front and rear panels are shown in Figures 3.1, and 3.2. The numbers with leaders to various controls in the figures are keyed to the entries in Table 3.1.

Table 3.1 - Entry Number Correlation

| NO. KEY | NAME         | FUNCTION  |
|---------|--------------|---|
| 1       | POWER        | A.C. line switch (ON/OFF) (Display serves as indicator light).  |
| 2       | Scale Expand | With button out, the display reads to 0.1K at all temperatures; with button in detent position, temperature reads to 0.01K below 30K, 0.05K between 30K and 100K, and to 0.1K above 100K. |
| 3       | Sensor B     | Selects Sensor B.   |
| 4       | Sensor A     | Selects Sensor A.   |
| 5       | NO LABEL     | Digital temperature display located behind filter panel. Sensor displayed depends on sensor selected.   |
| 6       | NO LABEL     | A.C. line cord  |
| 7       | Fuse         | A.C. line fuse  |
| 8       | Sensor A     | Sensor input lead terminals (Pin A, I+, Pin E, V+, Pin B, I-, Pin D, V-, Pin H, Shield).  |

|    |           |   |
|----|-----------|---|
| 9  | Monitor   | Analog output of sensor voltage (0-2.5V, Pin A) and optional linear analog output of temperature(0-4V, Pin C). Pin B is ground for sensor voltage while Pin D is ground for L/A output. |
| 10 | Sensor B  | Same as Sensor A  |
| 11 | Interface | BCD input of set point/output of temperature. Also IEEE interface port.   |

### 3.3 Temperature Readout

The sensor(s) and heater should be installed following the suggestions listed in the "Installation and Application Notes for Cryogenic Sensors" brochure in Section VIII.

Connect the sensor(s) to the instrument following the diagram in Figure 2.1.

Depress the power switch and observe that the display shows the proper temperature relative to the sample temperature.

The sensor and readout display should follow the curve in Table 3.2. This curve illustrates typical values expected of the DT-500-DRC or DT-500CU-DRC-36 sensors.

If the diode or lead wires are shorted, the display will read ----. If the diode is connected backwards, the display will read 428.0 for all curves. In the case of an open current or voltage lead, the display will slowly drift higher in temperature. The curves and appropriate PROM markings are given below:

| <u>Curve</u> | <u>PROM U13</u> |
|--------------|-----------------|
| O            | Version 3       |
| A            | Version 6       |
| B            | Version 2       |
| D            | Version 4       |
| E            | Version 5       |

If the instrument or sensor does not agree with values listed in the table, within the accuracy of the system, consult sections on installation and/or section on troubleshooting to determine the cause and cure of the malfunction.

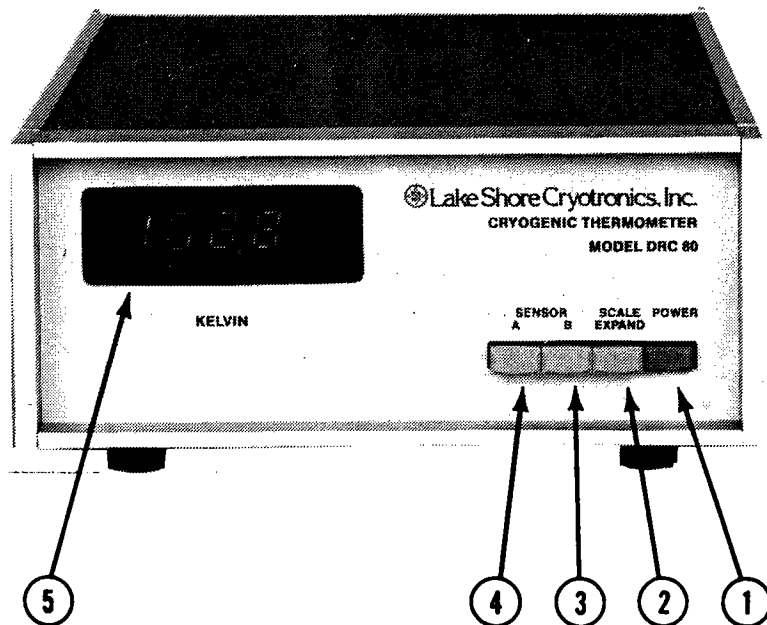


FIGURE 3.1 DRC-80 Front Panel

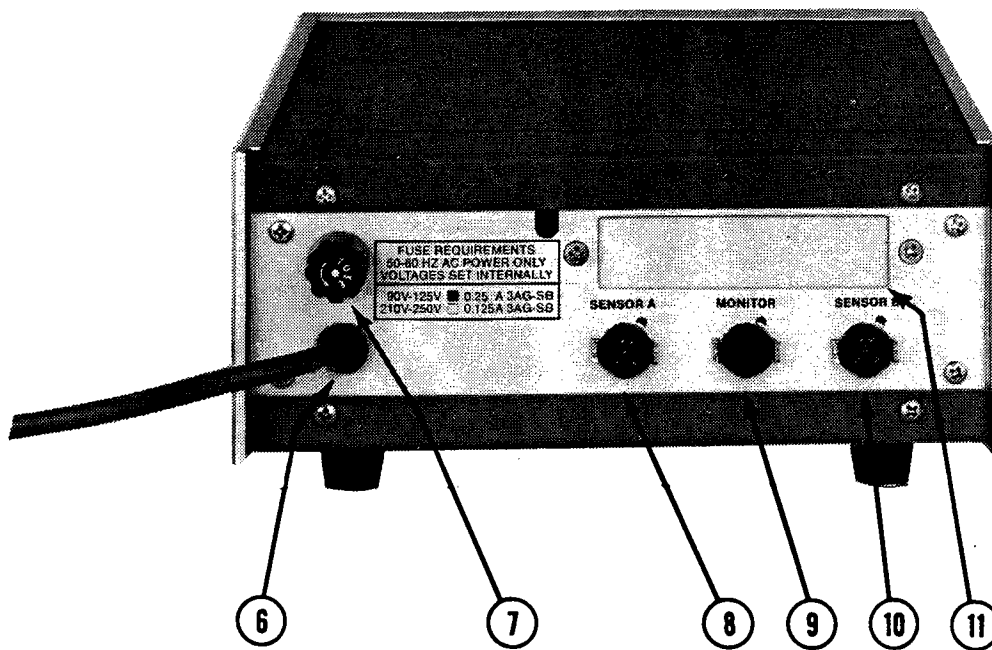


FIGURE 3.2 DRC-80 Rear Panel

Table 3.2

DT-500DRC (D) Voltage-Temperature Characteristic

| BP# | TEMP (K) | PROM VOLTAGE |
|-----|----------|--------------|
|     | 1.4      | 2.5984       |
|     | 1.5      | 2.5958       |
|     | 1.6      | 2.5932       |
|     | 1.7      | 2.5906       |
|     | 1.8      | 2.5880       |
| 30  | 1.9      | 2.5854       |
|     | 2.0      | 2.5828       |
|     | 2.2      | 2.5735       |
|     | 2.4      | 2.5643       |
|     | 2.6      | 2.5551       |
| 29  | 2.8      | 2.5458       |
|     | 3.0      | 2.5366       |
|     | 3.2      | 2.5226       |
|     | 3.4      | 2.5086       |
|     | 3.6      | 2.4946       |
|     | 3.8      | 2.4807       |
|     | 4.0      | 2.4667       |
|     | 4.2      | 2.4527       |
|     | 4.4      | 2.4387       |
|     | 4.6      | 2.4247       |
|     | 4.8      | 2.4108       |
|     | 5.0      | 2.3968       |
|     | 5.5      | 2.3618       |
|     | 6.0      | 2.3269       |
|     | 6.5      | 2.2919       |
| 28  | 7.0      | 2.2570       |
|     | 7.5      | 2.2220       |
|     | 8.0      | 2.1871       |
|     | 8.5      | 2.1521       |
|     | 9.0      | 2.1172       |
| 27  | 9.5      | 2.0909       |
|     | 10.0     | 2.0646       |
|     | 11.0     | 2.0119       |
|     | 12.0     | 1.9592       |
|     | 13.0     | 1.9066       |
| 26  | 14.0     | 1.8338       |
|     | 15.0     | 1.7610       |
| 25  | 16.0     | 1.6984       |
|     | 17.0     | 1.6359       |
|     | 18.0     | 1.5646       |



## DT-500DRC (D) Voltage-Temperature Characteristic

| BP# | TEMP (K) | PROM VOLTAGE |
|-----|----------|--------------|
| 24  | 19.0     | 1.4932       |
|     | 20.0     | 1.4219       |
|     | 21.0     | 1.3505       |
|     | 22.0     | 1.3006       |
| 23  | 23.0     | 1.2507       |
| 22  | 24.0     | 1.2114       |
|     | 25.0     | 1.1720       |
|     | 26.0     | 1.1486       |
|     | 27.0     | 1.1308       |
|     | 28.0     | 1.1190       |
| 18  | 29.0     | 1.1116       |
|     | 30.0     | 1.1058       |
|     | 32.0     | 1.0970       |
|     | 34.0     | 1.0902       |
|     | 36.0     | 1.0850       |
| 14  | 38.0     | 1.0798       |
|     | 40.0     | 1.0746       |
|     | 45.0     | 1.0633       |
|     | 50.0     | 1.0520       |
|     | 55.0     | 1.0407       |
| 12  | 60.0     | 1.0287       |
|     | 65.0     | 1.0166       |
|     | 70.0     | 1.0046       |
|     | 75.0     | .99172       |
|     | 80.0     | .97890       |
| 11  | 85.0     | .96609       |
|     | 90.0     | .95327       |
|     | 95.0     | .93987       |
|     | 100.0    | .92647       |
|     | 105.0    | .91307       |
| 10  | 110.0    | .89966       |
|     | 115.0    | .88626       |
|     | 120.0    | .87286       |
|     | 125.0    | .85946       |
|     | 130.0    | .84606       |
|     | 135.0    | .83228       |
|     | 140.0    | .81850       |
|     | 145.0    | .80472       |
|     | 150.0    | .79094       |
|     | 155.0    | .77716       |

DT-500DRC (D) Voltage-Temperature Characteristic

| BP# | TEMP (K) | PROM VOLTAGE |
|-----|----------|--------------|
| 9   | 160.0    | .76338       |
|     | 165.0    | .74961       |
|     | 170.0    | .73582       |
|     | 175.0    | .72170       |
|     | 180.0    | .70757       |
|     | 185.0    | .69344       |
|     | 190.0    | .67931       |
|     | 195.0    | .66518       |
|     | 200.0    | .65105       |
|     | 205.0    | .63693       |
| 8   | 210.0    | .62280       |
|     | 215.0    | .60867       |
|     | 220.0    | .59455       |
|     | 225.0    | .58080       |
|     | 230.0    | .56707       |
| 7   | 235.0    | .55334       |
|     | 240.0    | .53960       |
|     | 245.0    | .52649       |
|     | 250.0    | .51337       |
|     | 255.0    | .50026       |
| 6   | 260.0    | .48714       |
|     | 265.0    | .47403       |
|     | 270.0    | .46057       |
|     | 275.0    | .44711       |
|     | 280.0    | .43365       |
| 5   | 285.0    | .42019       |
|     | 290.0    | .40613       |
|     | 295.0    | .39208       |
| 4   | 300.0    | .37802       |
|     | 305.0    | .36397       |
|     | 310.0    | .34940       |
|     | 315.0    | .33482       |
|     | 320.0    | .32025       |
|     | 325.0    | .30568       |
|     | 330.0    | .29111       |
| 3   | 335.0    | .27654       |
|     | 340.0    | .26197       |
|     | 345.0    | .24739       |
|     | 350.0    | .23325       |
|     | 355.0    | .21911       |
| 2   | 360.0    | .20497       |
|     | 365.0    | .19083       |
|     | 370.0    | .17774       |
|     | 375.0    | .16464       |
| 1   | 380.0    | .15155       |

Table 3.2

DT-500DRC (E1) Voltage-Temperature Characteristic

| BP# | TEMP (K) | PROM VOLTAGE |
|-----|----------|--------------|
| 30  | 1.4      | 2.6591       |
|     | 1.5      | 2.6567       |
|     | 1.6      | 2.6542       |
|     | 1.7      | 2.6518       |
|     | 1.8      | 2.6494       |
| 29  | 1.9      | 2.6470       |
|     | 2.0      | 2.6446       |
|     | 2.2      | 2.6355       |
|     | 2.4      | 2.6265       |
|     | 2.6      | 2.6175       |
| 28  | 2.8      | 2.6084       |
|     | 3.0      | 2.5994       |
|     | 3.2      | 2.5868       |
|     | 3.4      | 2.5742       |
|     | 3.6      | 2.5616       |
| 27  | 3.8      | 2.5490       |
|     | 4.0      | 2.5364       |
|     | 4.2      | 2.5221       |
|     | 4.4      | 2.5077       |
|     | 4.6      | 2.4934       |
| 26  | 4.8      | 2.4791       |
|     | 5.0      | 2.4648       |
|     | 5.5      | 2.4290       |
|     | 6.0      | 2.3932       |
|     | 6.5      | 2.3574       |
|     | 7.0      | 2.3216       |
|     | 7.5      | 2.2858       |
|     | 8.0      | 2.2500       |
|     | 8.5      | 2.2142       |
|     | 9.0      | 2.1784       |
| 25  | 9.5      | 2.1516       |
|     | 10.0     | 2.1247       |
|     | 11.0     | 2.0708       |
|     | 12.0     | 2.0170       |
|     | 13.0     | 1.9632       |
| 24  | 14.0     | 1.9011       |
|     | 15.0     | 1.8390       |
|     | 16.0     | 1.7769       |
|     | 17.0     | 1.7148       |
|     | 18.0     | 1.6527       |

DT-500DRC (E1) Voltage-Temperature Characteristic

| BP# | TEMP (K) | PROM VOLTAGE |
|-----|----------|--------------|
| 23  | 19.0     | 1.5724       |
|     | 20.0     | 1.4922       |
|     | 21.0     | 1.4120       |
|     | 22.0     | 1.3317       |
|     | 23.0     | 1.2837       |
| 22  | 24.0     | 1.2357       |
| 21  | 25.0     | 1.1877       |
| 20  | 26.0     | 1.1559       |
| 19  | 27.0     | 1.1365       |
| 18  | 28.0     | 1.1239       |
| 17  | 29.0     | 1.1150       |
| 16  | 30.0     | 1.1080       |
| 15  | 32.0     | 1.0981       |
| 14  | 34.0     | 1.0909       |
| 13  | 36.0     | 1.0848       |
| 12  | 38.0     | 1.0797       |
|     | 40.0     | 1.0746       |
|     | 45.0     | 1.0630       |
|     | 50.0     | 1.0515       |
|     | 55.0     | 1.0399       |
| 11  | 60.0     | 1.0284       |
|     | 65.0     | 1.0159       |
|     | 70.0     | 1.0035       |
| 10  | 75.0     | 0.9911       |
|     | 77.35    | 0.9849       |
|     | 80.0     | 0.9780       |
| 9   | 85.0     | 0.9649       |
|     | 90.0     | 0.9518       |
|     | 95.0     | 0.9388       |
|     | 100.0    | 0.9257       |
|     | 105.0    | 0.9122       |
| 8   | 110.0    | 0.8988       |
|     | 115.0    | 0.8853       |
|     | 120.0    | 0.8718       |
|     | 125.0    | 0.8584       |
|     | 130.0    | 0.8449       |
|     | 135.0    | 0.8311       |
|     | 140.0    | 0.8173       |
|     | 145.0    | 0.8035       |
|     | 150.0    | 0.7896       |
|     | 155.0    | 0.7758       |

DT-500DRC (E1) Voltage-Temperature Characteristic

| BP# | TEMP (K) | PROM VOLTAGE |
|-----|----------|--------------|
| 7   | 160.0    | 0.7620       |
|     | 165.0    | 0.7482       |
|     | 170.0    | 0.7344       |
|     | 175.0    | 0.7202       |
|     | 180.0    | 0.7060       |
|     | 185.0    | 0.6918       |
|     | 190.0    | 0.6777       |
|     | 195.0    | 0.6635       |
|     | 200.0    | 0.6493       |
|     | 205.0    | 0.6351       |
| 6   | 210.0    | 0.6210       |
|     | 215.0    | 0.6068       |
|     | 220.0    | 0.5926       |
|     | 225.0    | 0.5789       |
|     | 230.0    | 0.5651       |
| 5   | 235.0    | 0.5514       |
|     | 240.0    | 0.5377       |
|     | 245.0    | 0.5246       |
|     | 250.0    | 0.5115       |
|     | 255.0    | 0.4984       |
| 4   | 260.0    | 0.4853       |
|     | 265.0    | 0.4722       |
|     | 270.0    | 0.4588       |
|     | 275.0    | 0.4454       |
|     | 280.0    | 0.4320       |
| 3   | 285.0    | 0.4186       |
|     | 290.0    | 0.4045       |
|     | 295.0    | 0.3904       |
|     | 300.0    | 0.3763       |
|     | 305.0    | 0.3622       |
| 2   | 310.0    | 0.3476       |
|     | 315.0    | 0.3330       |
|     | 320.0    | 0.3184       |
|     | 325.0    | 0.3038       |
|     | 330.0    | 0.2893       |
| 1   |          |              |

### 3.4 Analog Output of Temperature

The analog output of temperature takes the display temperature and converts it to an analog signal which has a sensitivity of 10 mV/K under normal operation. Under scale expand, this signal increases to 100 mV/K below 100K due to the movement of the decimal point. The analog output voltage is located on the monitor connector (Key 9 of Figure 3.2).

#### 3.4.1 Field Installation of DRC Options - 8022 and 8025

The installation of either the Model 8022 option (Parallel BCD) or 8025 (10 mV/K) can be done as follows:

- 1) Remove instrument cover.
- 2) Insert the model 8022/25 option board into instrument JE connector (the instrument has its edge card connector configured such that the option board can only be inserted in one way).
- 3) Take 50 pin ribbon connector, with mounting plate attached, and place it in Interface opening, J4 (after any existing plate is removed).

Note: Ribbon cable is only present for Model 8022 option.

- 4) Connect black (or green) and white wires of option board to 7 pin rear panel connector J3. White goes to pin C and black (or green) goes to pin D.
- 5) Replace instrument cover.

### 3.5 Standard DT-500DRC-and DT-500CU-DRC-36 Curves

The standard DT-500-DRC and DT-500CU-DRC-36 curve is explained in Section 3.3. The Tables include a list of PROM sensor voltages and break-points used in the linearization of the DRC curve to arrive at the correct temperature readout.

### 3.6 Rack Mounting the DRC-80

The DRC-80 cryogenic thermometer can be rack mounted with the RM-3H rack mounting hardware as shown in Figure 3.3. This hardware kit also allows the mounting of two style L half-rack units as shown in Figures 3.4 and 3.5.

### 3.7 The 10-Sensor Selector Switch

The 10-Sensor Selector Switch includes an umbilical which ties to the DRC-80 main printed circuit board (via a 16-pin ribbon cable header which plugs into internal socket JC (see Figure 6.3, DRC-80 Component

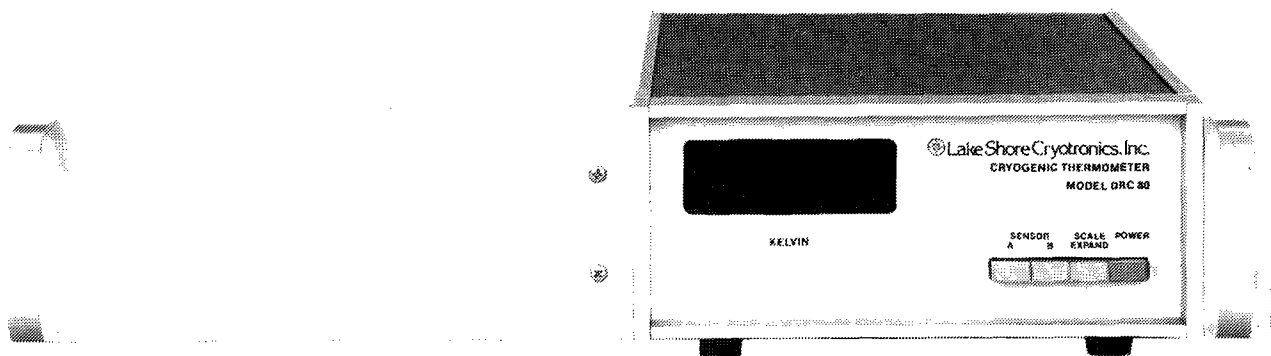


FIGURE 3.3 Model DRC-80 shown with RM-3H Rack Mounting Hardware.

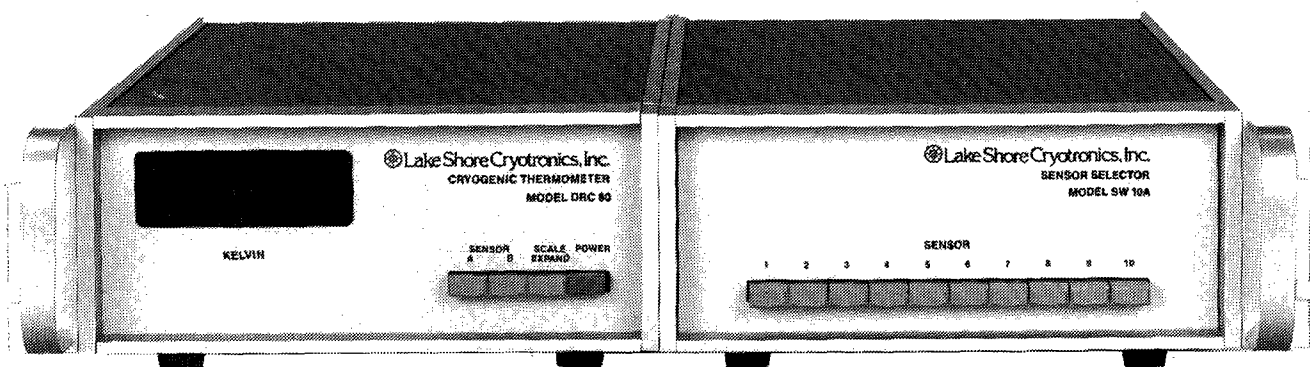


FIGURE 3.4 Model DRC-80 and SW-10A shown with RM-3H Rack Mounting Hardware.

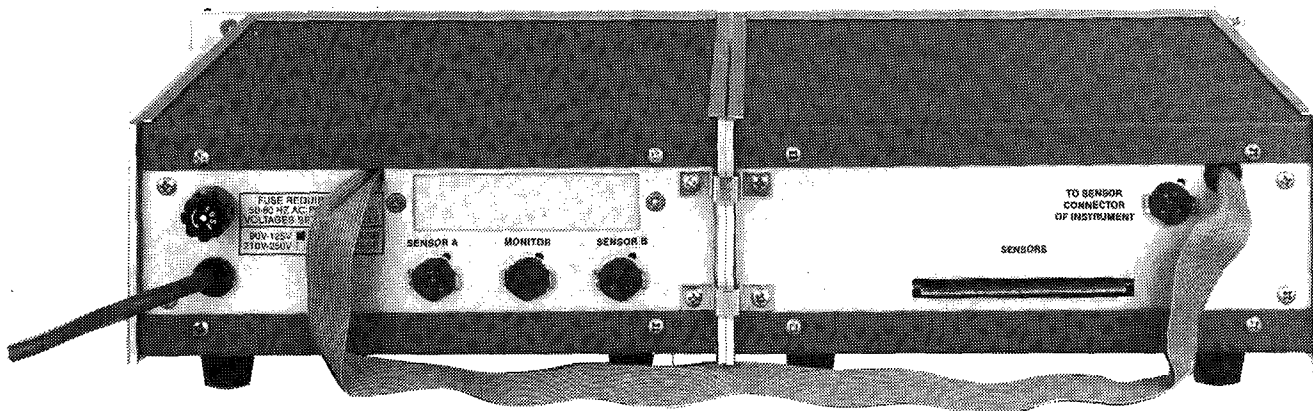


FIGURE 3.5 Model DRC-80 and SW-10A Rear View showing RM-3H Rack Mounting Hardware and Umbilical Cord Connections.

Layout) and a cable to connect the selected sensor leads to the DRC-80 (Sensor plug B is Key 10 of Figure 3.2).

The SW-10A is supplied with an 18" cable which is shielded and has male 5-pin amphenol connectors at each end (see Figure 3.5, SW-10A Option). This cable connects between J11 of the SW-10A and the B sensor plug of the DRC-80. Sensors are connected to the SW-10A via printed circuit edge J10. A 36-pin edge card connector and hood has been supplied with the SW-10A. Connectors to this edge J10 are given in Table 3.3. The hood mechanical assembly is given in Figure 6.9, SW-10A Hood Assembly.

Provisions have been made in the DRC-80 for setting the switch position which the instrument will see (S6). Since the software of the DRC-80 allows for calibrated curves to be programmed into the 10 positions of the SW-10A, a specific curve (or position) can be called up through the use of S6.

S6 is actually four switches (4 position dip switch). B0 (LSB) of switch position is between pins 1 and 8 and B3 (MSB) is between pins 4 and 5.

As an example, if the customer had precision options in positions 1, 2 and 3 of the DRC-80 and wanted to use dip switches to call up the curves (instead of the SW-10A umbilical), he could insert a four station dip switch and turn on or off the desired position.

Switch S6 should not be used in conjunction with 16 pin header JC of the SW-10A. The location for S6 is an 8 pin socket placed near JC (see Fig. 6.3, DRC-80 Component Layout).

### 3.8 Remote Parallel BCD Output Option

The BCD option consists of a 16 bit parallel output of temperature along with a scale expand bit to indicate decimal point, and a 4 bit output of switch position from the SW-10A.

Table 3.4 can be used for output line coding. The BCD out is handled through connector J4 (denoted on back panel as INTERFACE), a 50 pin connector on the rear panel of the instrument.

Data latches internal to the instrument provide a 1-2-4-8 code using positive logic with standard TTL levels of 0.4 volts or less for low (logic 0) and 2.4 volts or higher for the high (or 1) state under full load conditions. The drivers are sufficient to drive two standard loads, 3.2 mA, in the low state.

The sensor temperature output is externally gated through the use of an internally generated data valid pulse.



Table 3.3

## SW-10A CONNECTOR DETAIL

| Function | Sensor | Edge Connector Contact |
|----------|--------|------------------------|
| Shield   | All    | 1                      |
| I-       | All    | 2                      |
| V+       | 1      | A                      |
| V-       | 1      | B                      |
| I+       | 1      | 3                      |
| V+       | 2      | C                      |
| V-       | 2      | D                      |
| I+       | 2      | 4                      |
| V+       | 3      | E                      |
| V-       | 3      | F                      |
| I+       | 3      | 5                      |
| V+       | 4      | H                      |
| V-       | 4      | J                      |
| I+       | 4      | 6                      |
| V+       | 5      | K                      |
| V-       | 5      | L                      |
| I+       | 5      | 7                      |
| V+       | 6      | M                      |
| V-       | 6      | N                      |
| I+       | 6      | 8                      |
| V+       | 7      | P                      |
| V-       | 7      | R                      |
| I+       | 7      | 9                      |
| V+       | 8      | S                      |
| V-       | 8      | T                      |
| I+       | 8      | 10                     |
| V+       | 9      | U                      |
| V-       | 9      | V                      |
| I+       | 9      | 11                     |
| V+       | 10     | 17                     |
| V-       | 10     | 18                     |
| I+       | 10     | 12                     |

Table 3.4

BCD TEMPERATURE OUTPUT - MODEL DRC-SERIES  
REMOTE OUTPUT

2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50

1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49

| BCD TEMPERATURE OUTPUT |        | BCD TEMPERATURE OUTPUT |       |
|------------------------|--------|------------------------|-------|
| PIN                    |        | PIN                    |       |
| 1                      | 800/80 | 2                      |       |
| 3                      | 400/40 | 4                      |       |
| 5                      | 200/20 | 6                      |       |
| 7                      | 100/10 | 8                      |       |
| 9                      | 80/8   | 10                     |       |
| 11                     | 40/4   | 12                     |       |
| 13                     | 20/2   | 14                     |       |
| 15                     | 10/1   | 16                     |       |
| 17                     | 8/.8   | 18                     |       |
| 19                     | 4/.4   | 20                     |       |
| 21                     | 2/.2   | 22                     |       |
| 23                     | 1/.1   | 24                     |       |
| 25                     | .8/.08 | 26                     |       |
| 27                     | .4/.04 | 28                     |       |
| 29                     | .2/.02 | 30                     | SW-B0 |
| 31                     | .1/.01 | 32                     | SW-B1 |

| BCD TEMPERATURE OUTPUT |                                | BCD TEMPERATURE OUTPUT |          |
|------------------------|--------------------------------|------------------------|----------|
| PIN                    |                                | PIN                    |          |
| 33                     | Data Valid                     | 34                     | Ground   |
| 35                     | Trend Bit<br>1 - .01<br>0 - .1 | 36                     | SW-B2    |
| 37                     | SW-B3                          | 38                     |          |
| 39                     | Not used                       | 40                     | + 5V     |
| 41                     |                                | 42                     |          |
| 43                     |                                | 44                     |          |
| 45                     |                                | 46                     |          |
| 47                     |                                | 48                     |          |
| 49                     | Not used                       | 50                     | Not used |

### 3.9 IEEE Interface Option

The IEEE interface option available for the DRC-80 fully complies with the IEEE standard 488-1978 and incorporates the functional, electrical and mechanical specifications of the standard.

#### 3.9.1 General IEEE Specifications and Operation

The following discussion covers the general operation of the IEEE-488 interface. For a more detailed description of signal level and interaction, refer to the IEEE Std. 488-1978 publication "IEEE Standard Digital Interface for Programmable Instrumentation".

All instruments on the interface bus must be able to perform the interface functions of TALKER, LISTENER, or CONTROLLER. A TALKER transmits data onto the bus to other devices. A LISTENER receives data from other devices through the bus. Some devices perform both functions. The CONTROLLER designates to the devices on the bus which function to perform.

The IEEE works on a party line basis with all devices on the bus connected in parallel. All the active circuitry of the bus is contained within the individual devices with the cable connecting all the devices in parallel to allow the transfer of data between all devices on the bus.

There are 16 signal lines contained on the bus and consist of:

- A) 8 Data Lines
- B) 3 Byte Transfer Control Lines
- C) 5 General Interface Management Lines

The data lines consist of 8 signal lines that carry data in a bit parallel, byte serial format. These lines carry universal commands, addresses, program data, measurement data, and status to all the devices on the bus. The controller designates the functions of the units on the bus by setting the ATN line low (true) and sending talk or listen addresses on the DATA lines. When the ATN line is low, all devices listen to the DATA lines. When the ATN line goes high (false), then the devices addressed to send or receive data perform their functions while all others ignore the DATA lines.

Transfer of the information on the data lines is accomplished through the use of three signal lines: DAV (Data Valid), NRFD (Not Ready For Data), and NDAC (Not Data Accepted). These signals operate in an interlocking handshake mode. The two signal lines, NRFD, and NDAC are each connected in a logical AND to all devices connected to the bus. The DAV is sent by the talker and received by listeners while the NRFD and NDAC are sent by listeners back to the talker.

The General Interface Management Lines manage the bus and control the orderly flow of commands on the bus. The IFC (Interface Clear) message

basically clears the interface to a known state appropriate to the device being addressed. SRQ (Service Request) is used by a device to indicate the need for attention or service and to request an interruption of data flow. REN (Remote Enable) is used to select between two sources of device data (as an example: front panel or rear panel controls on a measurement device). EOI (End or Identify) indicates the end of a multiple byte transfer sequence, or along with the ATN line, executes a polling sequence.

The following table shows cable connector contact wiring for the IEEE-488 bus:

| Contact | Signal Line | Contact | Signal Line |
|---------|-------------|---------|-------------|
| 1       | DI01        | 13      | DI05        |
| 2       | DI02        | 14      | DI06        |
| 3       | DI03        | 15      | DI07        |
| 4       | DI04        | 16      | DI08        |
| 5       | EOI(24)     | 17      | REN(24)     |
| 6       | DAV         | 18      | Gnd(6)      |
| 7       | NRFD        | 19      | Gnd(7)      |
| 8       | NDAC        | 20      | Gnd(8)      |
| 9       | IFC         | 21      | Gnd(9)      |
| 10      | SRQ         | 22      | Gnd(10)     |
| 11      | ATN         | 23      | Gnd(11)     |
| 12      | SHIELD      | 24      | Gnd(LOGIC)  |

Note: Gnd(n) refers to the signal ground return of the referenced contact. EOI and REN return on contact 24.

### 3.9.2 Specific Operation of the DRC8-IEEE Interface, Model 8024

The DRC-8-IEEE Model 8024 provides a digital output of temperature in Kelvin, as well as the status of the front panel switches and SW-10 switch position.

Address and function selection are made via a switch package located on the rear panel of the DRC-80 (see Figure 3.6, DRC-IEEE Panel Layout). Positions 4-8 of the switch are the address switches for the interface with 4 being the most significant bit and 8 being the least significant bit. As an example: with switches 5, 6, and 7 ON (or down), and switches 4 and 8 OFF (or up), the address selected is 14 (or E base 16). The DRC-80 IEEE Interface is a talker only. The talk mode can be de-selected by turning switch 3 ON (or down).

Switch position 1 is used to select the order in which the output delimiters are put onto the IEEE bus. The following table gives the delimiter orientation versus switch position:

| <u>Switch 1 Position</u> | <u>Delimiter Order<br/>(Delm 1)(Delm 2)</u> |
|--------------------------|---|
| Up (OFF)                 | (LF) (CR)                                   |
| Down (ON)                | (CR) (LF)                                   |

The use of this switch allows the DRC8-IEEE to interface to controllers which accept both forms of delimiters to terminate input strings. NOTE: the address switches are updated on power up only. The address and delimiter orientation is read only when the instrument is turned on. Any change in the address switch while the instrument is on will be ignored.

The DRC8-IEEE transmits and receives all characters in ASCII. The cable connector meets IEEE-488, 1978 standards and is polarized for proper cable insertion.

In the talker mode the interface outputs switch settings, front panel settings, and display temperature. The data is output in the form of two string variables. After each of the variables is output, delimiters DELM 1 and DELM 2 are transmitted. After the second variable, the last delimiter has the EOI line set for end of transmission.

NOTE: In programming for an input from the DRC8-IEEE interface two string variables must be used (or read into the computer) or the interface will hang up, waiting to output all of the data. In outputting data to an array, the array must have enough elements to allow the input of both variables from the DRC8-IEEE interface (in this case the number of elements is 13).

Since there are two sets of delimiters output, and most computers use these delimiters to terminate string variables, the need for two string variables arises. An example of a transmission is as follows:

| <u>Function</u> | <u>Format for Data</u> | <u>Format Limits (X)</u> |
|-----------------|------------------------|--------------------------|
| Front Panel     | XX(DELM1)(DELM2)       | 0-9, A-F                 |
| Temperature     | XXXX.XX(DELM1)(DELM2)  | numerics only            |

The two front panel characters are output in a packed format with individual bits representing a piece of data. The front panel indicators are denoted as follows:



### 3.9.3. Sample Programming

This section contains some sample programming for the DRC8-IEEE option.

#### 3.9.3.1 Commodore Pet/CBM 2001

Set the address switch to 6 by putting address switches 6 and 7 down; 8, 5 and 4 up. Make sure switch 3 is up (off) to allow the DRC8-IEEE to talk. Set switch 1 up (off) to select (LF)(CR) as the delimiter orientation. NOTE: The address switch is updated only on power up. Connect the CBM IEEE cable to the DRC8-IEEE interface. Turn on the PET and enter the program below, including line numbers, by pressing the RETURN key after every line. After entering the program, type RUN and press the RETURN key. The display will then return the data from the instrument.

```
10 OPEN2.6
20 INPUT#2,P$,T$
30 CLOSE2
40 PRINT
50 PRINT
60 PRINT"PANEL          ";P$
70 PRINT"TEMPERATURE";T$
80 END
```

#### 3.9.3.2 HP-85

Set the address switch to 6 by putting address switches 6 and 7 down; 8, 5 and 4 up. Make sure switch 3 is up (off) to allow the DRC8-IEEE to talk. Set switch 1 down (on) to select (CR)(LF) as the delimiter orientation. NOTE: The address switch is updated only on power up. Connect the DRC8-IEEE to the IEEE interface of the HP-85. Turn on the unit and enter the program below, including line numbers, by pressing the END LINE key after every line. Press the RUN key. The display will then return the data from the instrument.

```
10 ENTER706;P$,T$
20 PRINT
30 PRINT
40 PRINT"PANEL          ";P$
50 PRINT"TEMPERATURE";T$
60 END
```

#### 3.9.3.3 HP-9845B

Set the address switch to 6 by putting address switches 6 and 7 down; 8, 5 and 4 up. Make sure switch 3 is up (off) to allow the DRC8-IEEE to talk. Set switch 1 down (on) to select (CR)(LF) as the delimiter orientation. NOTE: The address switch is updated only on power up. Connect the DRC8-IEEE to the 98034A IEEE interface of the 9845B. Turn on the unit and enter the program below, including line numbers, by pressing the STORE

key after each line is entered. Press the RUN key. The display will then return the data from the instrument.

```
10 DIMP$[5],T$[10]
20 ENTER706;P$,T$
30 PRINT
40 PRINT
50 PRINT"PANEL      ";P$
60 PRINT"TEMPERATURE";T$
70 END
```

#### 3.9.3.4 HP-9825A

Set the address switch to 6 by putting address switches 6 and 7 down; 8, 5 and 4 up. Make sure switch 3 is up (off) to allow the DRC8-IEEE to talk. Set switch 1 down (on) to select (CR)(LF) as the delimiter orientation. NOTE: The address switch is updated only on power up. Connect the DRC8-IEEE to the 98034A IEEE interface of the 9825A. Turn on the unit and enter the program below by pressing the STORE key after each line is typed. Press the RUN key. The printer will read the data from the instrument.

```
0 dim P$[5],T$[10]
1 red 706,P$,T$
2 prt P$
3 prt T$
4 end
```

#### 3.9.3.5 HP-9835A

Set the address switch to 6 by putting address switches 6 and 7 down; 8, 5 and 4 up. Make sure switch 3 is up (off) to allow the DRC8-IEEE to talk. Set switch 1 down (on) to select (CR)(LF) as the delimiter orientation. NOTE: The address switch is updated only on power up. Connect the DRC8-IEEE to the 98034A interface of the HP-35A. Turn on the unit and enter the program below by pressing the STORE key after each line is typed. Press the RUN key. The display will return the data from the instrument.

```
10 ENTER706;P$,T$
20 PRINT
30 PRINT
40 PRINT"PANEL      ";P$
50 PRINT"TEMPERATURE";T$
60 END
```



#### 3.9.4 Field Installation of DRC-IEEE, Model 8024

The DRC8-IEEE Model 8024 is easily field installed as follows:

- 1) Remove instrument cover.
- 2) Remove blank plate from Interface opening, J4.
- 3) Plug 24 pin umbilical into DRC-80 board connector JD<sup>1</sup>  
(see Fig. 6.3, DRC-80 Component Layout).
- 4) Place Model 8024 board in the unit and install with  
screws. (Component side up).
- 5) Replace instrument cover.

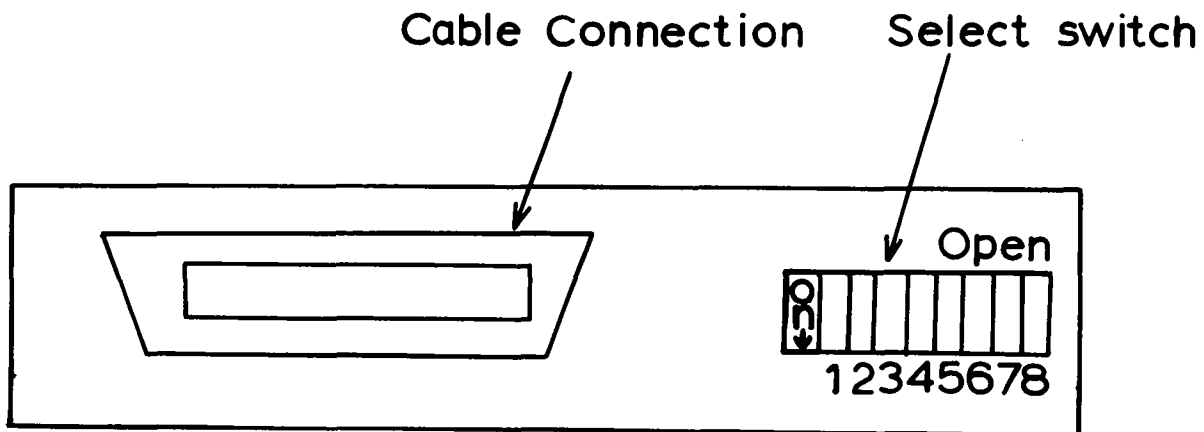


Figure 3.6 DRC80-IEEE  
Panel Layout

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## SECTION IV

### Theory of Operation

#### 4.1 Introduction

The Lake Shore DRC-80 is the ideal Cryogenic Thermometer for lab or system use. Its features, options, and accessories enable it to handle routine measurements or complex multi-point monitoring assignments with equal ease.

Its wide measurement range covers the spectrum of most cryogenic temperature needs. The dual-sensor input enables two sensors to be used concurrently, either for verification or for monitoring temperature at different points. This multi-input capability can be further expanded with the Model SW-10A, 10-position Selector Switch which conveniently mounts side-by-side with the 80 in a standard 3½" rack opening. Sensor selection is via front-panel pushbuttons.

The display sensor voltage is fed to an Analog-to-Digital converter pair (A/D), where it is converted to a digital voltage signal proportional to the sensor voltage. The multiplexed BCD outputs from the A/D are sampled and verified by the microprocessor. The microprocessor executes a program which takes the sampled sensor voltage and, using break point voltage and temperature information stored in a tabular array, calculates the associated Kelvin temperature to better than 0.01 Kelvin. The microprocessor then outputs the temperature information to the display board. The decoder/driver decodes this temperature data, latches the information and drives the display digits.

The sensor display voltage is also available as a buffered output through the monitor plug on the rear of the instrument.

The microprocessor also controls the BCD and IEEE options.

#### 4.2 Detailed Description

A detailed description of the operation of the DRC instrument is outlined in the following sections. The Figures required for each section will be denoted in that discussion.

##### 4.2.1 Power Supplies

Please refer to Figure 6.1 (Schematic #1) for the following discussion. There are four different power supplies incorporated in the DRC-80 instrument. The main power transformer, TX1, has split primaries for 115 or 230 volt AC operation. The slide switch, S2, selects the proper line voltage.

The first secondary is output through leads 1 and 3. This secondary is rectified by CR1 and a floating 15 volt supply is obtained through C1, C5, and the positive 15 volt regulator U1. This supply is used to power the constant current source for the diode.

The second secondary, through leads 2, 4, and 6, is a full wave bridge rectified by CR2-5. A +15 volt supply is generated by C2, C6 and a positive 15 volt regulator U2. The negative 15 volt supply is generated by C3, C7 and voltage regulator U3. Both these supplies are used in the A/D converter, the buffer section, and the L/A option.

The third secondary is through leads 8, 10, and 12 and is full wave rectified by CR6-7. The five volt supply that is used by the TTL IC's is formed by C4, C8, and a 5 volt positive voltage regulator U4.

#### 4.2.2 Precision Constant Current Source and Front Panel Switching

A 10 $\mu$ A floating constant current source is used to excite either Sensor A or B depending on the switch position chosen by the front panel switches, S5 (Sensor A) or S4 (Sensor B).

A precision reference voltage is generated by an internally stabilized precision voltage reference (U5) and resistor R1 which determines the bias current for the zener reference. Resistor R6 has a nominal 499K value so that when the voltage picked off the stable reference is close to 4.99V, the output current determined by the operational amplifier (U6) and the output FET(U7) will be exactly 10 $\mu$ A with a compliance voltage greater than 10V.

The 10 $\mu$ A current is directed to Sensor A or Sensor B by the switch S5. Switch S4 directs the positive sensor voltage of Sensor A or B to the A/D converter pair. Note that both the Sensor A and Sensor B low voltage terminals are tied together to analog ground. Therefore, the I<sup>-</sup> return of the current source will be slightly below ground (by a few millivolts, depending on lead resistance). Since S5 and S4 are interlocking switches, the switch S4 is used to tell the microprocessor which sensor has been selected. This information is important to the microprocessor only if a calibrated sensor is present or if a SW-10A ten-position switch option is present in Sensor position B.

Switch S3 indicates to the microprocessor whether or not scale expand below 100K is desired.

Switch S1 is the ON-OFF switch. Power ON is indicated by a lighted display board.

#### 4.2.3 A/D Converter and Microprocessor System

The analog-to-digital convertor consists of a high input impedance precision 4½ digit I.C. pair (8052A/7103A, U12 and U10) that produces a BCD output that is accurate to  $\pm 1$  count over its entire 40,000 count

range. The 7103A (U10) runs on a 50K Hz clock cycle generated by a 7555 clock (U11) and its associated components (R11, R12, and C11). This clock frequency allows for one reading every 0.8 seconds. The digital output signal is in a bit-parallel, byte serial form. The A/D converter output is multiplexed by U14 and U15 and input to the microprocessor.

In addition to the A/D voltage information, the microprocessor inputs the sensor-selected, scale expand switch position, and in the case of the SW-10A, the position selected. The microprocessor outputs temperature information in BCD form to the display as well as to the options (BCD or IEEE), if present. If a ten-position switch is also present, the sensor position selected is also output to the option (BCD or IEEE).

The microprocessor system used in the DRC-80 is a 38P70 which utilizes a piggy-back memory architecture. A 3870 $\mu$ p was originally a mask-memory part with the user tied to one program form when the part was fabricated. The piggy-back variation of the part allows for variable memory space (between 8K and 64K of PROM) to be placed on the top of the  $\mu$ p. This allows all lines that were used for addresses and data to be used for Input/Output.

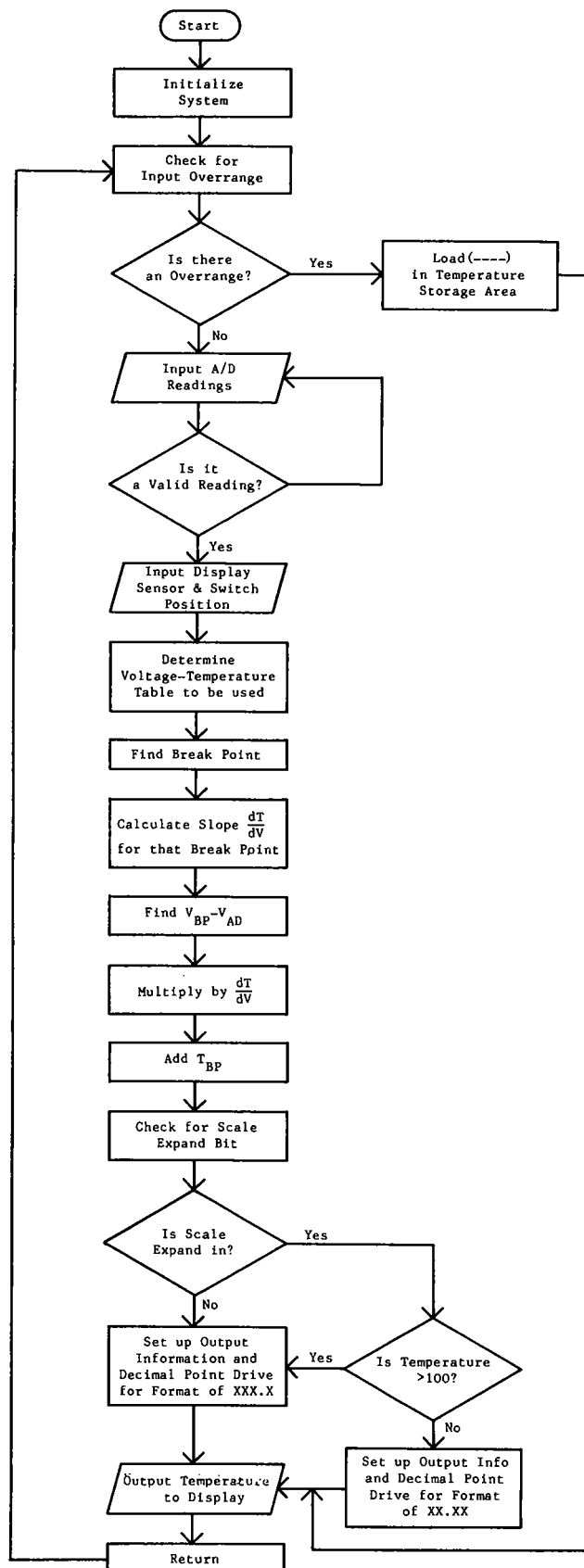
The microprocessor unit (MPU) has an internal RAM scratchpad memory used for programming. The unit uses an internally generated clock which is derived from the resistor from R21 (and C21 if needed). The MPU has 4 8-bit bi-directional ports used for communication to and from the processor. Two of these ports, Port 0 and 5, are used for internal control of the instrument (A/D input, BCD temperature output to BCD L/A option and display, and internal housekeeping). The remaining two ports, Port 1 and 4, are used for option access (IEEE-488).

#### 4.2.4 Software - DRC-80 Cryogenic Thermometer

Figure 4.1 is a flow chart of the major steps in the cryogenic thermometer program. When the instrument is turned on, the program does a power ON reset and starts the software program at the beginning. At this point, the program initializes internal registers to be used in the program. The program first checks for an A/D converter overrange and then inputs multiplexed A/D information. When the A/D tells it there is fresh data ready, (the program loops until the A/D information is ready), the program then verifies that no illegal characters are present and stores the reading.

The program then inputs display sensor information. There is one standard curve for the instrument and there are a maximum of twelve additional curves. There can be a calibrated curve for Sensor A, B, and ten different switch positions generated by the SW-10A. The program, through the use of some internal identifiers, determines the proper curve to be used.

Once the curve is determined, the proper Voltage-Temperature Break



**FIGURE 4.1** Software Flow Diagram for DRC-80 Digital Thermometer

Point is determined. The program finds the correct break point for temperature determination by checking each breakpoint voltage to see if it is lower than the input voltage. As the break point is found, the temperature is calculated using the following equation:

$$T = (V_{BP} - V_{AD}) * \frac{dT}{dV} + T_{BP}$$

where:

|                         |  |
|-------------------------|--|
| T                       | is temperature in K                      |
| V <sub>BP</sub>         | is break point voltage                   |
| V <sub>AD</sub>         | is input voltage                         |
| $\frac{dT}{dV}(S_{BP})$ | is slope between successive break points |
| T <sub>BP</sub>         | is break point temperature               |

After the correct temperature has been calculated, the program looks to see if the instrument is in the scale expand mode. In this mode, the front panel display converts to a resolution of .01K below 30K and 0.05K between 30K and 100K. The temperature data is output in a bit-parallel, digit-serial form and is latched into the display board.

#### 4.2.5 Digital Display Board

The display board receives its data in a bit-parallel/digit-serial form. The information is latched into the display decoder/driver, U101, which drives the display digits DS1-4.

Control of the decimal point is carried out by the BCD/decimal decoder/driver, U102. This driver receives its information directly from the microprocessor.

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## SECTION V

### Calibration and Troubleshooting

#### 5.1 Introduction

This section contains the instructions for calibrating and troubleshooting the DRC-80 instrument.

#### 5.2 Test Equipment

A high input impedance digital voltmeter and oscilloscope, and a precision resistor connected to simulate the diode wired according to Figure 2.1 (b) are normally sufficient to test and calibrate the DRC-80 instrument.

#### 5.3 General Remarks

On installation, one of the major problems is an improperly connected temperature sensing diode. It is advised that other portions of the cryogenic system be tested before the instrument is troubleshooted. Some checks that could be made are:

- 1) Open or shorted sensor leads (especially in an area of frequent disassembly).
- 2) Leakage paths between heater and sensor leads that induce electrical feedback in addition to thermal feedback.

If the malfunction points toward the instrument, more detailed tests should be made.

#### 5.4 Instrument Calibration

The DRC-80 has been factory calibrated. If a recalibration is needed, the following procedure should be followed. Please refer to the component layout for the DRC-80, Figure 6.3 for the following discussion:

##### 5.4.1 Current Source

A precision resistor of not less than .01% tolerance should be connected across pins A and B (Figure 2.1) of the A Sensor socket. A high input impedance voltmeter connected across the precision resistor should measure a voltage equal to 10 microamperes times the value of the resistor. For example, a 100K ohm  $\pm$ .01% resistor should read 1.0000 volts within 100  $\mu$ volts. If recalibration is needed, the voltage across the 100K resistor can be adjusted by varying resistor R3.

#### 5.4.2 A/D Converter

To adjust the A/D converter, a voltage needs to be applied across pins E and D (Figure 2.1) of the display sensor connector. A variable 200K resistor hooked up as in Fig. 2.1 (a), or precision voltage source in place of the diode are ideal ways to generate this voltage. If a resistor is used, it should be varied until one of the breakpoint voltages, indicated in the Voltage-Temperature Characteristic Table is generated; (A high impedance voltmeter must be used for this adjustment). After an appropriate voltage is obtained, the display should be calibrated by adjusting trimpot R16 until the display reads the correct temperature. If a precision voltage source is used, a breakpoint voltage should be dialed in and the display should be calibrated as above. A breakpoint temperature above 40K should be used since the voltage sensitivity with temperature is lower at the higher temperatures ( $2.5 \text{ mV}/^{\circ}\text{K}$ ) than for temperatures below 30K.

#### 5.4.3 Adjustment of Output Buffer

With a constant voltage fed into the instrument, place a voltmeter between pins A & B of connector J3. U9 is a buffer of input voltage and should have an output equal to input. R4 is varied to obtain the proper buffered signal.

#### 5.4.4 DRC8-L/A Option Model 8025 (if present)

The output of the DRC8-L/A Model 8025 is  $10 \text{ mV}/^{\circ}\text{K}$  in the normal display mode. In other words,  $100.0^{\circ}\text{K}$  on the display corresponds to a 1.0000V output between pins C and D of monitor connector J3. To recalibrate the option, two adjustments need to be made. With a low temperature on the display (e.g.,  $22.0^{\circ}\text{K}$ ), adjust the offset adjustment potentiometer R89 (see Fig. 6. , DRC-80 BCD L/A Layout) until the output corresponds to  $10 \text{ mV}/^{\circ}\text{K}$ . Then take the display to a higher temperature (e.g.,  $300^{\circ}\text{K}$ ). Adjustment of Gain Potentiometer R88 will bring the output to  $10 \text{ mV}/^{\circ}\text{K}$ . The procedure may need one more iteration, that is, go to the low temperature on the display, adjust the offset, then adjust the gain.

#### 5.5 Instrument Tests

The first check to be made would be to check the input line fuse. The type of fuse and line voltage are shown on the rear panel of the instrument. If the input line voltage and sensor input voltage have been checked, the following sequence should be followed:

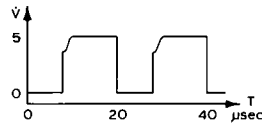
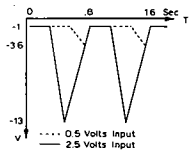
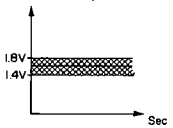
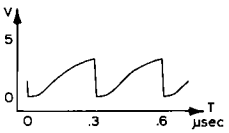
- 1) Check all power supplies for proper operation. The voltages can be noted on Fig. 6.3, DRC-80 Parts Layout.
- 2) Check for the waveforms at the following pins and refer to Fig. 5.1 for waveforms.

Signal paths should also be checked. If signals are present at source components and not at destination components, a printed circuit problem requiring a repair of the printed circuit foil may be required. Continuity checks between points will turn up any unwanted open circuits in signal paths.

If the signals at the component pins outlined in Table 5.1 are present, and a problem still exists, a factory representative should be contacted.

Table 5.1

DRC-80 Signals Associated with Figure 5.1

| Signal                                 | Function  | Wave Form   |
|--|---|---|
| a) Pin 12 of U10<br>or<br>Pin 3 of U11 | Clock signal of A/D converter. The frequency should be about 50K Hz. If not present, replace U11. Also check R12, R11, and C11.   |    |
| b) Pin 14 of U12                       | Integrated signal of A/D to determine the count period. The period should be about .35 seconds. If not present, check U10 and U11.  |   |
| c) Pin 7 of U10                        | This is a D.C. level that is the reference voltage for the integrator. The value should be between 1.4 and 1.8 volts. If not present, check U12. Also check resistance string R15-18 for proper value and operation.  |  |
| d) A/D Output<br>of U10                | The digit drives (Pins 19, 24, 25, 26, and 27) are positive going pulses and last for 200 clock pulses. The scan sequence is D5 (MSD), D4, D3, D2, and D1 (LSD). The BCD pins (pins 20-23) are positive going signals that go on simultaneously with the digit device. If not present, and signals a), b), and c) are correct, replace U10. | See Figure 5.1 on following page  |
| e) Pin 2 of U13                        | This is the $\mu$ P clock signal. This is generated by an external RC network with the help of the main processor. If not present, check R21, C21, and U13 for proper operation.  |  |

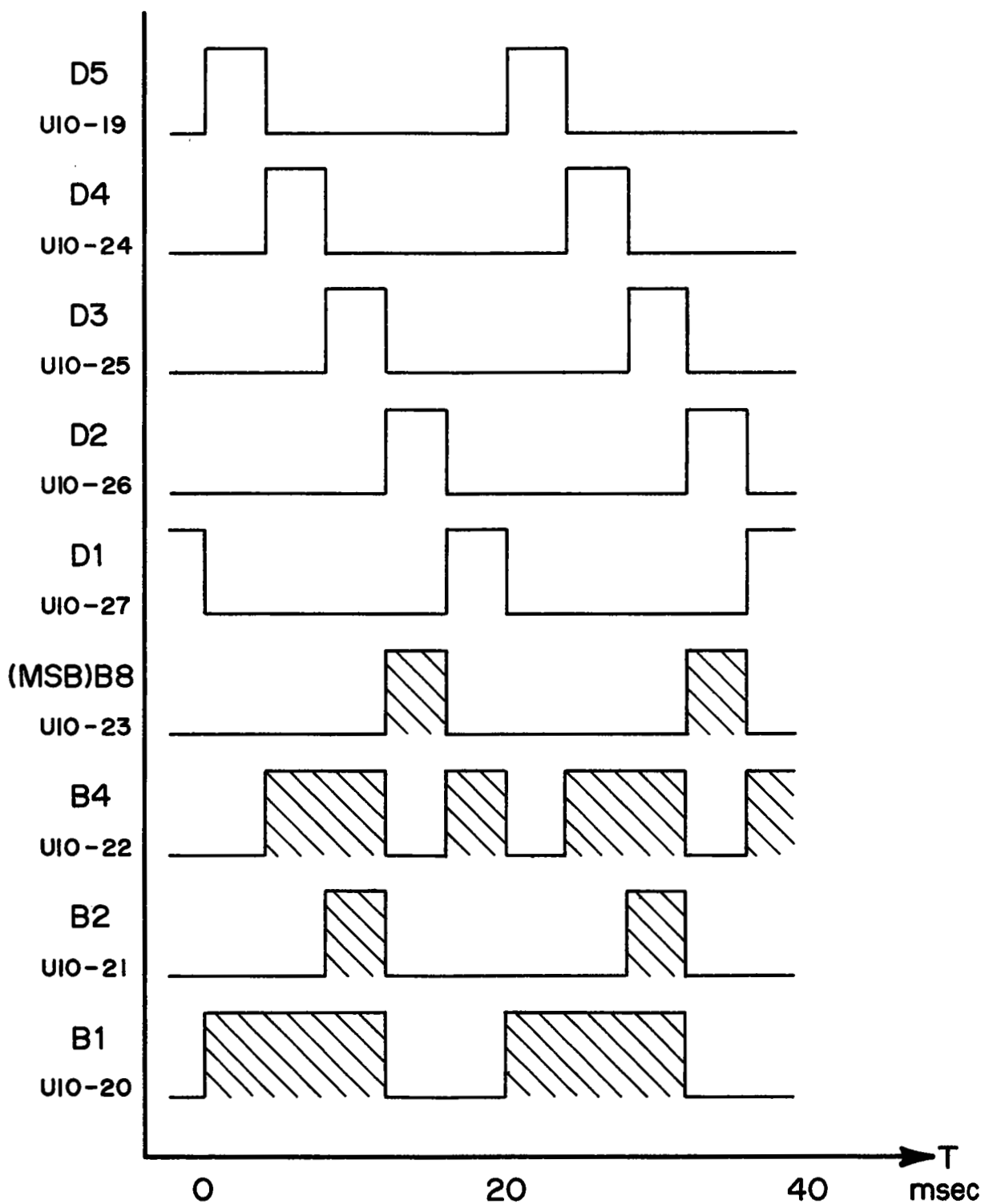


Figure 5.1 DRC-80 A/D Typical Output Signals

## SECTION VI

DRC-80  
REPLACEABLE PARTS LISTCAPACITORS

| CIRCUIT<br>DESIGNATION | VALUE         | RATING | TYPE     |
|------------------------|---------------|--------|----------|
| C1                     | 470 $\mu$ f   | 35V    | E. AL.   |
| C2                     | 470 $\mu$ f   | 35V    | E. AL.   |
| C3                     | 470 $\mu$ f   | 35V    | E. AL.   |
| C4                     | 2700 $\mu$ f  | 25V    | E. AL.   |
| C5                     | .1 $\mu$ f    | 100V   | Poly.    |
| C6                     | .1 $\mu$ f    | 100V   | Poly.    |
| C7                     | .1 $\mu$ f    | 100V   | Poly.    |
| C8                     | .68 $\mu$ f   | 100V   | Poly.    |
| C9                     | 150 $\mu$ f   | 500V   | Mica D.  |
| C10                    | .0015 $\mu$ f | 100V   | Mylar    |
| C11                    | 330 pf        | 500V   | Mica. D. |
| C12                    | .68 $\mu$ f   | 100V   | Poly.    |
| C13                    | 1.5 $\mu$ f   | 25V    | Tan.     |
| C14                    | 330 pf        | 500V   | Mica D.  |
| C15                    | .33 $\mu$ f   | 100V   | Mylar    |
| C16                    | .68 $\mu$ f   | 100V   | Poly.    |
| C17                    | .68 $\mu$ f   | 100V   | Poly.    |
| C18                    | .68 $\mu$ f   | 100V   | Poly.    |
| C19                    | .33 $\mu$ f   | 100V   | Mylar    |
| C20                    | .68 $\mu$ f   | 100V   | Poly.    |
| C21                    | 18 pf         | 500V   | Mica D.  |
| C22                    | .1 $\mu$ f    | 100V   | Poly.    |

CONNECTORS

| CIRCUIT<br>DESIG. | DESCRIPTION                            | MFR. and PART NO.                        |
|-------------------|--|--|
| J1                | 5 Pin Socket<br>(Sensor A)             | Amphenol 126-218<br>(mates with 126-217) |
| J2                | 5 Pin Socket<br>(Sensor B)             | Amphenol 126-218<br>(mates with 126-217) |
| J3                | 7 Pin Socket                           | Amphenol 126-198<br>(mates with 126-195) |
| J4                | BCD Out/IEEE Out<br>(Interface)        | Lake Shore<br>Cryotronics, Inc.          |
| JA                | 10 Contact PC Mount<br>(Display Board) | AMP MOD II 3-86018-5<br>(mates to JG)    |

### CONNECTORS

| CIRCUIT<br>DESIG. | DESCRIPTION   | MFR. and PART NO.                         |
|-------------------|---|---|
| JB                | 10 Contact PC Mount<br>(Display Board                   | AMP MOD II 3-86018-5<br>(mates to JH)     |
| JC                | 14 Pin IC Socket<br>(SW-10 Input of<br>switch position) | Cambion<br>703-5314-01-04-12              |
| JD                | 16 Pin IC Socket<br>(IEEE Micro Interface)              | Cambion<br>703-5316-01-04-12              |
| JE                | 24 Contact Edge Card<br>(BCD/L-A Option)                | TRW 50-24B-10                             |
| JG                | 10 Contact PC Mount<br>(To Display Board)               | AMP MOD II 87228-5<br>(mates to JA)       |
| JH                | 10 Contact PC Mount<br>(To Display Board)               | AMP MOD II 87228-5<br>(mate to JB)        |
| JL                | 12 Contact PC Mount<br>(Power Transformer)              | AMP 350213-1<br>(mates to 1-480<br>287-0) |

### DIODES

| CIRCUIT<br>DESIG. | TYPE                                      | MFR. and PART NO.         |
|-------------------|---|---------------------------|
| CR1               | Silicon                                   | IN4006                    |
| CR2               | Silicon                                   | IN4006                    |
| CR3               | Silicon                                   | IN4006                    |
| CR4               | Silicon                                   | IN4006                    |
| CR5               | Silicon                                   | IN4006                    |
| CR6               | Silicon                                   | MR501                     |
| CR7               | Silicon                                   | MR501                     |
| CR8               | Silicon                                   | IN743A                    |
| CR9               | Silicon                                   | IN743A                    |
| CR10              | Silicon                                   | IN4148                    |
| DS1               | 7 Segment LED<br>(Least significant LED)  | Hewlett-Packard 5082-7651 |
| DS2               | 7 Segment LED<br>(2nd Significant Digit)  | Hewlett-Packard 5082-7651 |
| DS3               | 7 Segment LED<br>(3rd Significant Digit)  | Hewlett-Packard 5082-7651 |
| DS4               | 7 Segment LED<br>(Most Significant Digit) | Hewlett-Packard 5082-7651 |

# INTEGRATED CIRCUITS

| CIRCUIT<br>DESIGNATION | DESCRIPTION  | MFR. and PART NO.                        |
|------------------------|--|--|
| U1                     | 15V Positive<br>Voltage Regulator                      | 7815                                     |
| U2                     | 15V Positive<br>Voltage Regulator                      | 7815                                     |
| U3                     | 15V Negative<br>Voltage Regulator                      | 7915                                     |
| U4                     | 5V Positive<br>Voltage Regulator                       | 7805                                     |
| U5                     | Temp. Stabilizer Voltage<br>Reference (Current Source) | LM399H                                   |
| U6                     | Operational Amplifier                                  | LM308N                                   |
| U7                     | F.E.T. (Current Source<br>Driver)                      | 3N163                                    |
| U8                     | Not Present  |  |
| U9                     | Operational Amplifier                                  | OP07EJ                                   |
| U10                    | A/D Converter<br>Building Block                        | 71C03                                    |
| U11                    | Timer Circuit  | 7555                                     |
| U12                    | A/D Converter<br>Building Block                        | 8052                                     |
| U13                    | Microprocessor Unit                                    | 38P70<br>Plus Prom<br>(Memory Dependent) |
| U14-15                 | Tri-State<br>4-line to 4-line<br>Multiplexers          | 74LS257                                  |

# MISCELLANEOUS

| CIRCUIT DESIG.<br>or FIG. NO. | DESCRIPTION   | MFR. and PART NO.   |
|-------------------------------|---|---|
|                               | Main Fuse<br>3 AG, Slow Blow<br>90V-125:3/4A<br>210V-250V:4/10A<br>Fuseholder | Bussmann MDL 3/4<br>Bussmann MDL 4/10<br>Littlefuse 342004A |
| TX1                           | Power Transformer   | LSCI Supplied<br>TX696-107                                  |
|                               | Power Cord 115V<br>CEE Color Coded 230V<br>Strain Relief                      | Belden 17236<br>Belden 17740C<br>H.H. Smith 939             |
|                               | Heat Sink for U4  | Aavid 60130-020B  |

# RESISTORS

| CIRCUIT<br>DESIGNATION | VALUE       | RATING                       | TYPE  |
|------------------------|-------------|------------------------------|-------|
| R1                     | 3.74K       | 1% ½W                        | Mt.F. |
| R2                     | 10K         | 1% ½W                        | Mt.F. |
| R3                     | 5K Trimpot  | I Source Adjust.             |       |
| R4                     | 20K Trimpot | Operational Amplifier Adjust |       |
| R5                     | 4.75K       | 1% ½W                        | Mt.F. |
| R6                     | 499K        | 1% ½W                        | Mt.F. |
| R7                     | Not Present |                              |       |
| R8                     | Not Present |                              |       |
|                        | Not Present |                              |       |
| R10                    | 4.75K       | 1% ½W                        | Mt.F. |
| R11                    | 10K         | 1% ½W                        | Mt.F. |
| R12                    | 33.2K       | 1% ½W                        | Mt.F. |
| R13                    | 36.5K       | 1% ½W                        | Mt.F. |
| R14                    | 301K        | 1% ½W                        | Mt.F. |
| R15                    | 1.18K       | 1% ½W                        | Mt.F. |
| R16                    | 5K Trimpot  | A/D Adjust                   |       |
| R17                    | 196 ohm     | 1% ½W                        | Mt.F. |
| R18                    | 107 ohm     | 1% ½W                        | Mt.F. |
| R19                    | 121K        | 1% ½W                        | Mt.F. |
| R20                    | 121K        | 1% ½W                        | Mt.F. |
| R21                    | 19.6K       | 1% ½W                        | Mt.F. |
| R22                    | 4.75K       | 1% ½W                        | Mt.F. |
| R23                    | 10 ohm      | 1% ½W                        | Mt.F. |
| R24-27                 | 4.7K        | 4 Element Resistance Network |       |
| R101                   | 3.74K       | 1% ½W                        | Mt.F. |
| R102-105               | 330 ohm     | 4 Element Resistance Network |       |

# SWITCHES

| CIRCUIT<br>DESIGNATION | DESCRIPTION         | MFR. and PART NO.     |
|------------------------|---------------------|-----------------------|
| S1                     | Power Switch        | LSCI Supplied, DRC-80 |
| S3                     | Scale Expand Switch | LSCI Supplied, DRC-80 |
| S4                     | Sensor B            | LSCI Supplied, DRC-80 |
| S5                     | Sensor A            | LSCI Supplied, DRC-80 |
| S2                     | 115/230 Switch      | Switchcraft           |
| S6                     | Not Present         |                       |



DRC-80 BCD L/A  
REPLACEABLE PARTS LIST

CAPACITORS

| CIRCUIT<br>DESIGNATION | VALUE  | RATING | TYPE  |
|------------------------|--------|--------|-------|
| C56                    | .033 f | 100V   | Mylar |
| C57                    | .68 f  | 100V   | Poly. |
| C58                    | .68 f  | 100V   | Poly. |
| C59                    | .68 f  | 100V   | Poly. |

CONNECTOR

| CIRCUIT<br>DESIGNATION | DESCRIPTION            | MFR. and PART NO.       |
|------------------------|------------------------|-------------------------|
| J4                     | 50 pin PC Mount Header | T&B Ansley<br>609-5022M |

INTEGRATED CIRCUITS

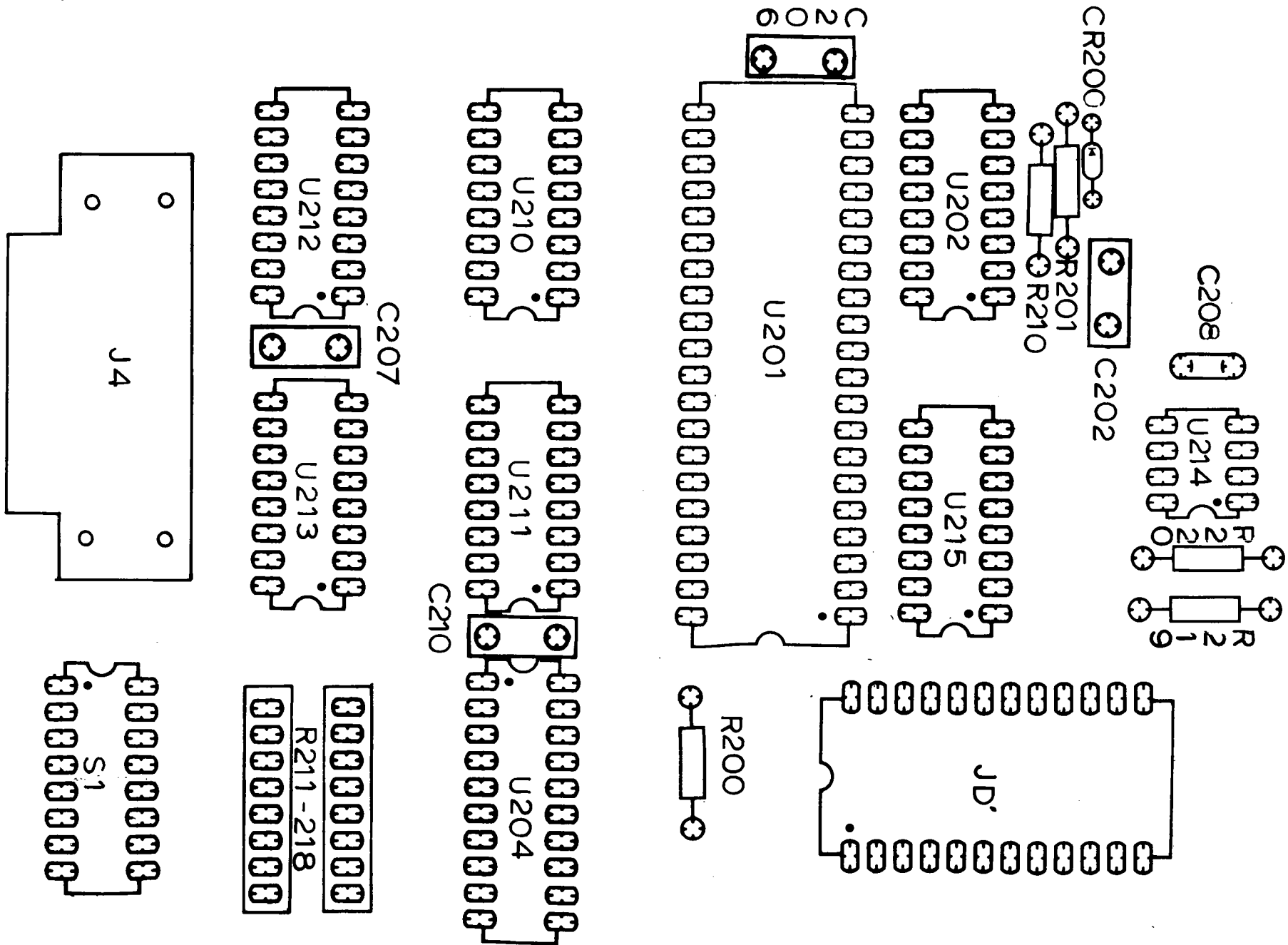
| CIRCUIT<br>DESIGNATION | USED IN  | PART NO.  |
|------------------------|----------|-----------|
| U51                    | BCD, L/A | 74LS175   |
| U52                    | BCD, L/A | 74LS175   |
| U53                    | BCD, L/A | 74LS175   |
| U54                    | BCD, L/A | 74LS175   |
| U56                    | BCD only | 74123     |
| U61                    | L/A only | OP15FJ    |
| U62                    | L/A only | DAC HP16D |
| U63                    | BCD, L/A | 7420      |


RESISTORS

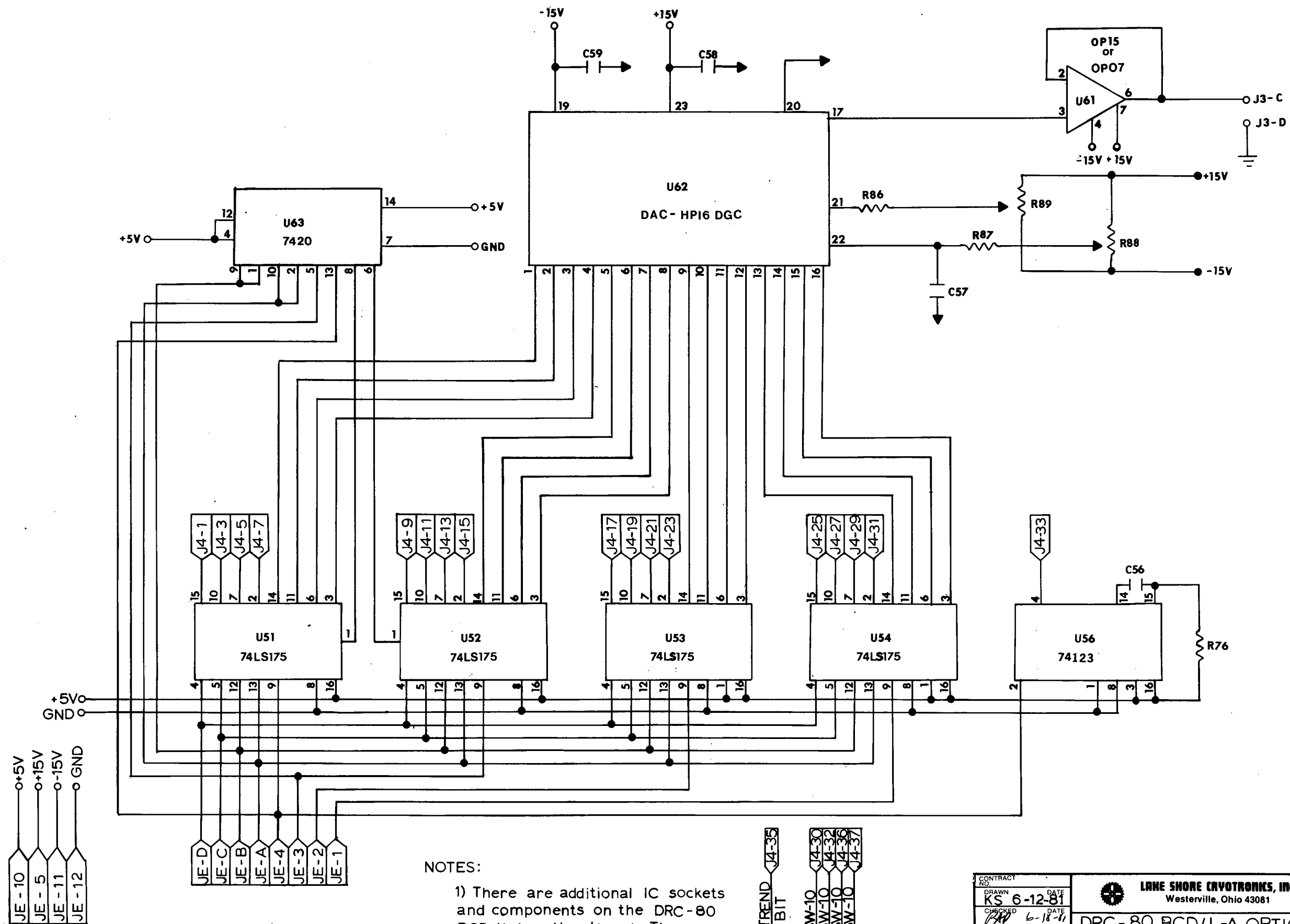
| CIRCUIT<br>DESIGNATION | VALUE       | RATING             | TYPE  |
|------------------------|-------------|--------------------|-------|
| R76                    | 2 MEG       | 1% $\frac{1}{4}$ W | Mt.F. |
| R86                    | 2 MEG       | 1% $\frac{1}{4}$ W | Mt.F. |
| R87                    | 511K        | 1% $\frac{1}{4}$ W | Mt.F. |
| R88                    | 50K Trimpot |                    |       |
| R89                    | 50K Trimpot |                    |       |

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|  |  |  |  |                                    |          |
|--|--|--|--|------------------------------------|----------|
| CONTRACT NO.   |  |  |  <b>LAKE SHORE CRYOTRONICS, INC.</b><br>Westerville, Ohio 43081 |                                    |          |
| DRAWN <b>KS</b> DATE <b>6-19-81</b><br>CHECKED <b>PB</b> DATE <b>7-14-81</b><br>APP'D <b>PB</b> DATE <b>7-14-81</b><br>APP'D <b>ma</b> DATE <b>7-14-81</b> |  |  | <b>DRC 80 IEEE PARTS LAYOUT</b>  |                                    |          |
| CUSTOM PROTO. PROD.  |  |  | SIZE <b>B</b>  | DRWG. NO. <b>B - 204 - 81 - 01</b> | REVISION |
| DESIGN ACTIVITY  |  |  | SCALE  | SHEET                              | OF       |



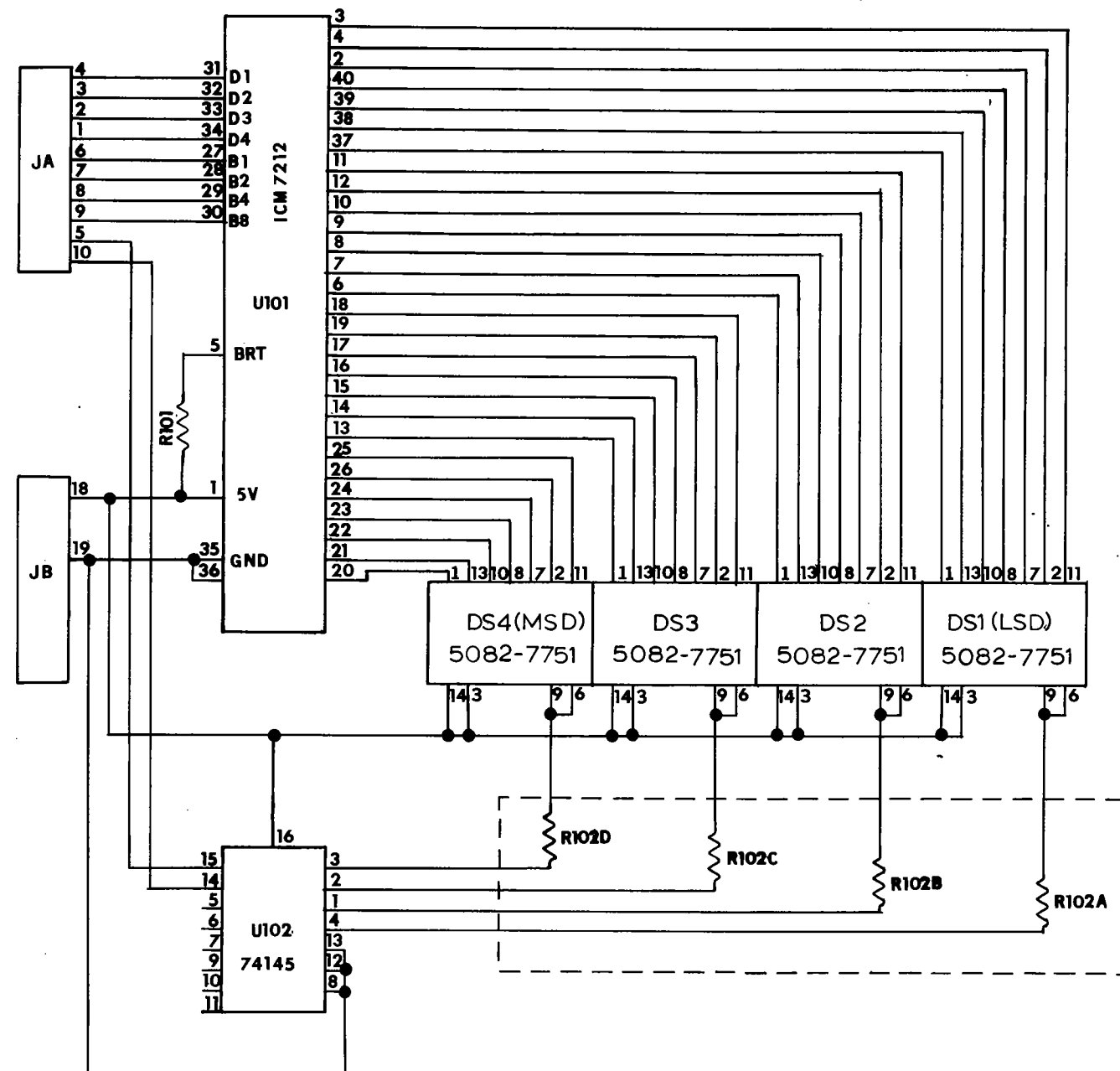
# NOTES:

1) There are additional IC sockets and components on the DRC-80 BCD/L-A option board. They serve no functional purpose.

JE-6 TREND BIT J4-35


BO JE-J SW-10 J4-30  
B1 JE-E SW-10 J4-32  
B2 JE-F SW-10 J4-36  
B3 JE-H SW-10 J4-37

|                  |  |              |  |                                 |  |
|------------------|--|--------------|--|---------------------------------|--|
| CONTRACT NO.     |  | DATE         |  | LAKE SHORE ELECTRONICS, INC.    |  |
| DRAWN KS 6-12-81 |  | DATE 6-18-81 |  | Westerville, Ohio 43081         |  |
| CHECKED          |  | DATE 6-18-81 |  | DRC-80 BCD/L-A OPTION SCHEMATIC |  |
| APP'D            |  | DATE 6-18-81 |  | SIZE C                          |  |
| CUSTOM           |  | PROTO        |  | DRWG. NO. C-169-81-01           |  |
| DESIGN ACTIVITY  |  | SCALE        |  | SHEET OF                        |  |

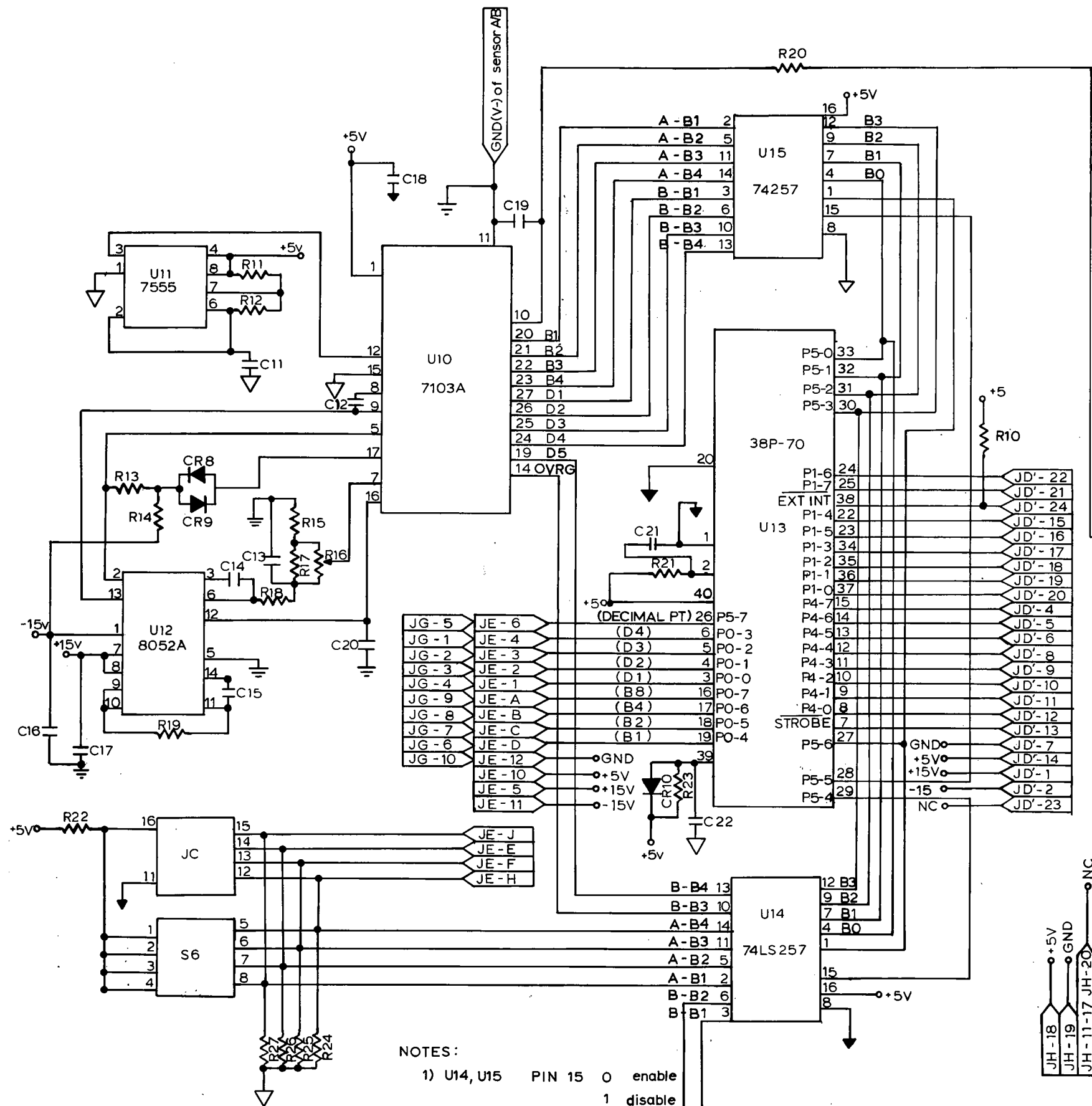


NOTES:

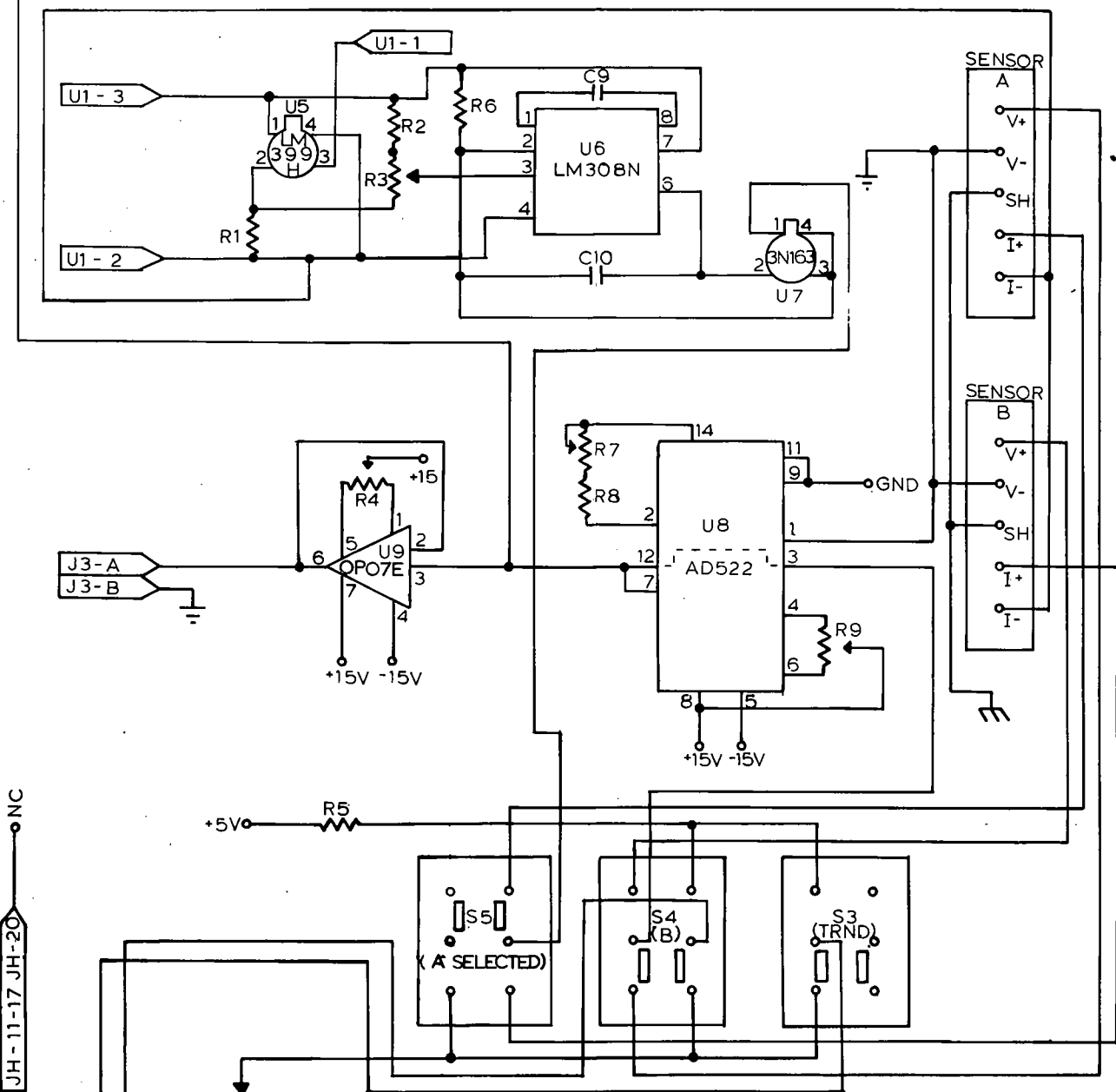
- 1) JA AND JB MATE TO MAIN BOARD CONNECTORS JG AND JH RESPECTIVELY.
- 2) PINS 5, 6, 7, 9, 10, 11 OF U102 ARE N.C.

|                 |  |         |  |  |  |
|-----------------|--|---------|--|--|--|
| CONTRACT NO.    |  | DATE    |  |  <b>LANE SHORE ELECTRONICS, INC.</b><br>Westerville, Ohio 43081 |  |
| DRAWN           |  | DATE    |  |  |  |
| KS 6-10-81      |  | 6-18-81 |  | <b>DRC 80 DISPLAY BOARD SCHEMATIC</b>  |  |
| CHECKED         |  | DATE    |  |  |  |
| Rita            |  | 6-18-81 |  | SIZE C<br>DRWG. NO: 168-81-01<br>REVISION  |  |
| APP'D           |  | DATE    |  |  |  |
| Rita            |  | 6-18-81 |  | SCALE<br>SHEET OF  |  |
| CUSTOM          |  | PROD.   |  |  |  |
| DESIGN ACTIVITY |  | SCALE   |  | SHEET OF   |  |





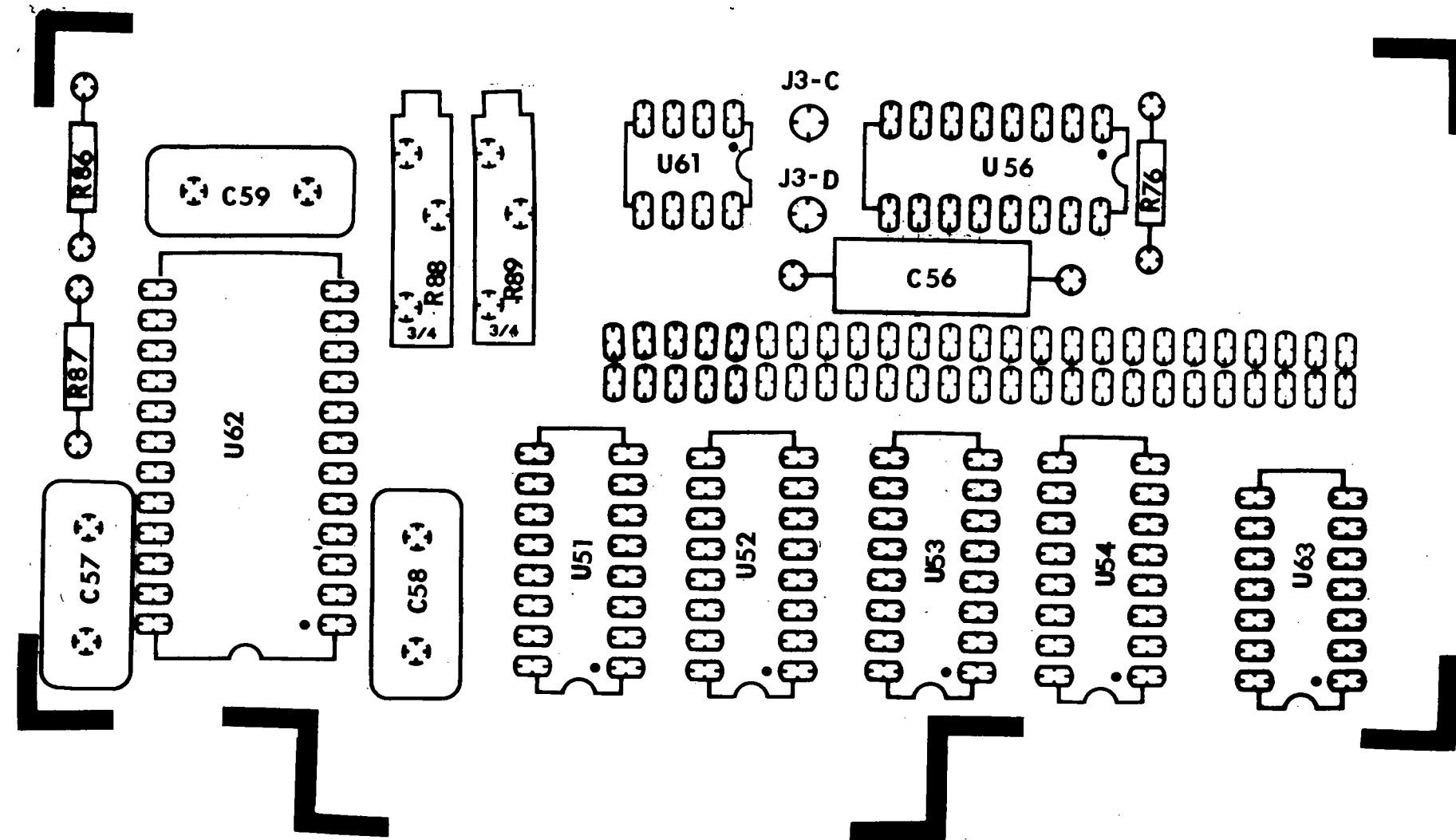
- NOTES:
- 1) U14, U15 PIN 15 0 enable  
1 disable  
PIN 1 0 A input  
1 B input
  - 2) C21 IS NOT PRESENT




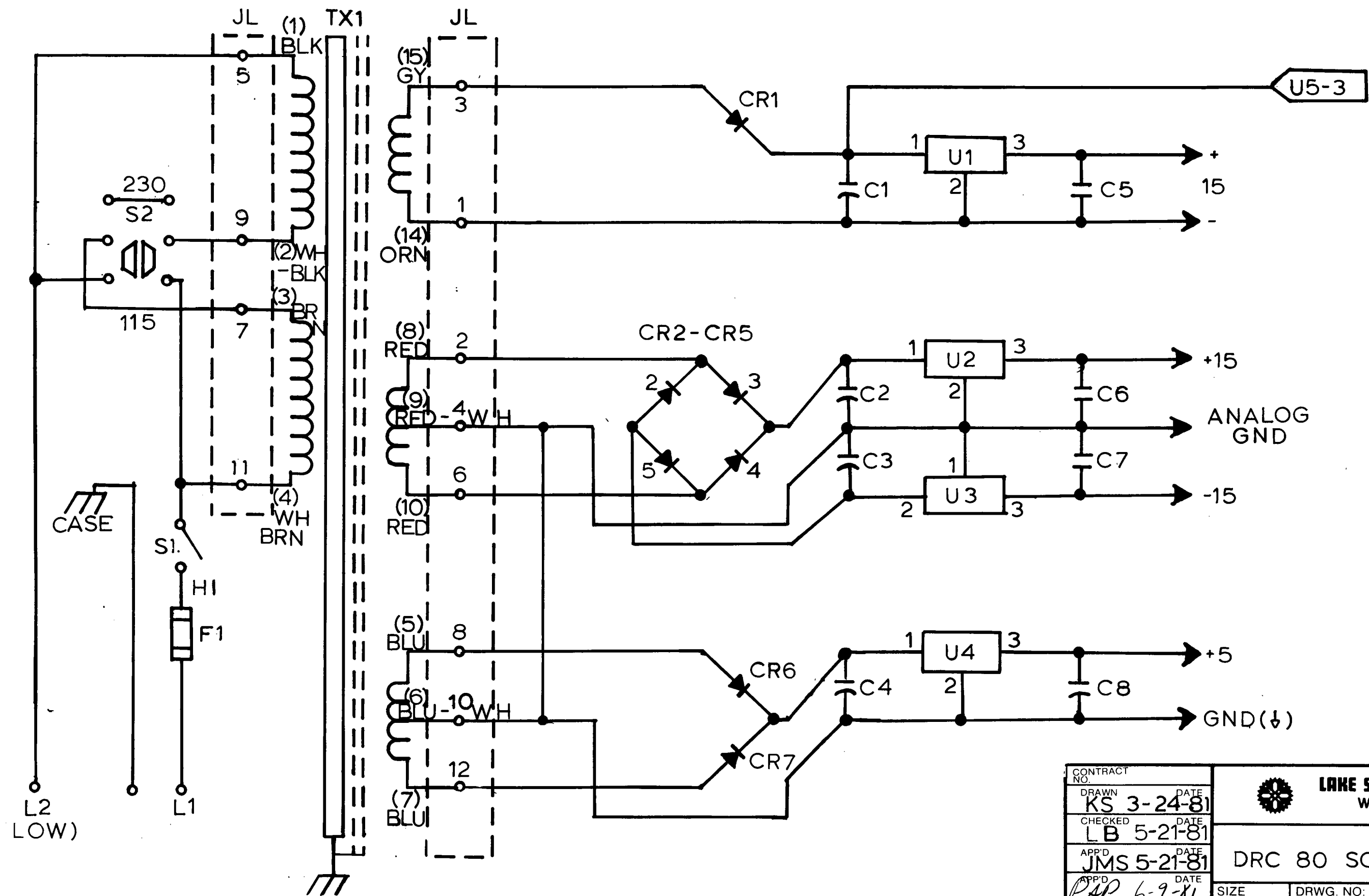
|                 |       |       |             |             |  |
|-----------------|-------|-------|-------------|-------------|--|
| CONTRACT NO.    |       | DATE  |             | KS 3-19-81  |  |
| DRAWN           |       | DATE  |             | LP 6-18-81  |  |
| CHECKED         |       | DATE  |             | JRP 6-11-81 |  |
| APPROVED        |       | DATE  |             | 6-19-81     |  |
| CUSTOMER        | PROJ. | SCALE | DRWG. NO.   | REVISION    |  |
| DESIGN ACTIVITY |       |       | D-145-81-01 |             |  |
| SCALE           |       |       | SHEET OF    |             |  |


LINE SHORE ELECTRONICS, INC.  
 Westerville, Ohio 43081  
 DRC-80 SCHEMATIC #2





|                 |        |  |  |  |
|-----------------|--------|--|--|--|
| CONTRACT NO.    |        |  <b>LAKE SHORE CRYOTRONICS, INC.</b><br>Westerville, Ohio 43081 |  |  |
| DRAWN           |        |  |  |  |
| DATE            |        | <b>DRC 80 BCD L/A PARTS LAYOUT</b>   |  |  |
| CHECKED         |        |  |  |  |
| DATE            |        | SIZE <b>B</b> DRWG. NO: <b>B - 203 - 81 - 01</b> REVISION  |  |  |
| APPRO'D         |        |  |  |  |
| DATE            |        | SCALE      SHEET      OF   |  |  |
| APPRO'D         |        |  |  |  |
| CUSTOM          | PROTO. | PROD.  |  |  |
| DESIGN ACTIVITY |        |  |  |  |



|                 |  |            |  |  |  |
|-----------------|--|------------|--|--|--|
| CONTRACT NO.    |  | DATE       |  |  <b>LAKE SHORE CRYOTRONICS, INC.</b><br>Westerville, Ohio 43081 |  |
| DRAWN           |  | DATE       |  |  |  |
| KS 3-24-81      |  | LB 5-21-81 |  | DRC 80 SCHEMATIC *1  |  |
| CHECKED         |  | DATE       |  | SIZE B   |  |
| JMS 5-21-81     |  | DATE       |  | DRWG. NO: B-178-81-01  |  |
| APP'D           |  | DATE       |  | REVISION   |  |
| PAP 6-9-81      |  | PROD.      |  | SHEET OF   |  |
| DESIGN ACTIVITY |  | SCALE      |  |  |  |